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RAPID RESPONSE RESEARCH AND DEVELOPMENT (R&D) FOR THE AEROSPACE SYSTEMS DIRECTORATE

Delivery Order 0004: Research for Propulsion and Power Systems, Volume 2 – Students Exploring Advanced Technologies (SEAT) Program

Various authors from associated educational institutions

Universal Technology Corporation
(Noble Solutions, LLC, compiler)

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Final Report

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AEROSPACE SYSTEMS DIRECTORATE
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7541
AIR FORCE MATERIEL COMMAND
UNITED STATES AIR FORCE

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14. ABSTRACT

The material in this report volume was developed by students in advanced aeronautical curricula programs. The SEAT Program was designed to create a collaborative partnership program between the Materials and Manufacturing Directorate of the Air Force Research Laboratory (AFRL/RX), Dayton Public Schools (DPS), Wilberforce University, and Central State University. The goal is to encourage high school students who display an aptitude in mathematics and science to pursue a college education. Encouragement was achieved through mentoring from Wilberforce science and engineering students and working with AFRL research scientists involved in the development of advanced manufacturing and materials technologies.

The SEAT Program leverages the existing local science fair or inquiry-based research (scientific or engineering methods) process to engage DPS students and provide a competitive focus. DPS students selected for the SEAT experience will be mentored to help them prepare and participate in local, regional, state and/or international science, math and engineering fairs. Winners in regional and/or state science fair categories will be offered summer hire positions working with scientists and engineers at AFRL.

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1.0 Purpose, Goals, and Scope

The SEAT Program was designed to create a collaborative partnership program between the Materials and Manufacturing Directorate of the Air Force Research Laboratory (AFRL/RX), Dayton Public Schools (DPS), Wilberforce University, and Central State University. The goal is to encourage high school students who display an aptitude in mathematics and science to pursue a college education. Encouragement was achieved through mentoring from Wilberforce science and engineering students and working with AFRL research scientists involved in the development of advanced manufacturing and materials technologies.

The need for the SEAT Program stems from research that shows that the United States has lost its position as the number one developed nation for high school students who surveys indicate are deciding to go to college. Additionally, too many college freshmen enroll in science and engineering and then find out it is not their calling and either drop out of college or change majors. SEAT provides high school students with an opportunity to experience the real world of scientists and engineers and to decide if that is the career field for their college education.

The SEAT Program leverages the existing local science fair or inquiry-based research (scientific or engineering methods) process to engage DPS students and provide a competitive focus. DPS students selected for the SEAT experience will be mentored to help them prepare and participate in local, regional, state and/or international science, math and engineering fairs. Winners in regional and/or state science fair categories will be offered summer hire positions working with scientists and engineers at AFRL.

2.0 Objectives

The objectives of the SEAT Program are to:

- Provide a structured outreach program between Academia, DPS, and AFRL for DPS students who demonstrate academic achievement in mathematics and science
- Afford DPS students an opportunity to experience real world applications of learned mathematics and science skills
- Promote collaboration between Historically Black Colleges and Universities (HBCUs), other academia, nonprofit organizations, and government laboratories.

3.0 Benefits

The benefits of successful implementation of the SEAT Program are expected to be:

- Increased number of DPS students attending college and graduating in the sciences and engineering
- Afford high school students attending a large urban school district the benefits and opportunities of pursuing a career with AFRL
- Increase collaborative efforts between academia, DPS, and AFRL, aimed at closing the academic achievement gaps in mathematics and science for large urban school districts.

4.0 Roles and Responsibilities

The broadly defined roles for the SEAT Program Sponsors and Partners are as follows:

4.1 Air Force Research Laboratory Directorates

- Participate as a SEAT (IPT) Member and commit to providing resources, personnel and facilities as appropriate to support the SEAT Program objectives
- Provide core Program funding for resource requirements
- Provide a secretariat to support the IPT to include facilitating meetings, recording and publishing minutes, tracking action items, and coordinating IPT activities.
- Provide AFRL on-site research opportunities for science fair participants through the existing AFRL Summer Hire Program
- Provide mentors and judges for high school science and math clubs, and local science fairs
- Promote the SEAT Program through appropriate publications, web sites, etc.
- Ensure that AFRL employees serving as mentors for selected SEAT participants on their science fair projects abide by all DPS rules for security, safety, and general conduct.
- Promote and host a tour of AFRL laboratory facilities at least one time per academic school year for secondary and primary students with the intent to encourage their pursuit of mathematics, science, and engineering studies.

4.2 Dayton Public Schools

- Participate as a SEAT IPT Member and commit to providing resources, personnel and facilities as appropriate to support the SEAT Program objectives
- Provide a credentialing process (background check) for undergraduate students prior to assigning them work with SEAT participants
- Ensure that Dayton Public Schools faculty, students, and other participating employees abide by all Air Force and AFRL rules for security, safety, and general conduct.
- Develop a science and math fair track for DPS high school students
- Identify and select high school students for the SEAT Program
- Provide teachers and staff to serve as academic coaches for competitive high school science fairs
- Promote the SEAT Program through appropriate publications, web sites, etc.

4.3 HBCU

- Participate as a SEAT IPT Member and commit to providing resources, personnel and facilities as appropriate to support the SEAT Program objectives
- Assist DPS develop a science fair track for DPS high school students
- Mentor DPS students in the preparation for and participation in local, regional, state, and international science fairs
- Develop metrics, with concurrence of the SEAT IPT, for measuring SEAT Program progress and success
- Promote the SEAT Program through appropriate publications, web sites, etc.
- Promote and host tours for secondary and primary students with the intent to encourage their pursuit of mathematics, science, and engineering studies.

- Ensure that HBCU faculty, students, and other participating employees abide by all Air Force and AFRL rules for security, safety, and general conduct.
- Ensure that HBCU faculty and staff members serving as mentors for selected SEAT Participants on their science fair projects abide by all DPS rules for security, safety, and general conduct.

5.0 Program Implementation Strategy

5.1 SEAT Implementation Strategy

The SEAT Program was implemented using students selected to attend the Academic Magnet Academy (AMA) at Colonel White High School, which was in its second year of operation. Col White High School became Thurgood Marshall High School that has officially received it Ohio Department of Education designation as Science, Technology, Engineering and Math (STEM) School.

5.1.1 Motivating Students

Look at possible solutions to motivating students to enhance the quality of their math and science research projects. One possible solution is offering select SEAT Participants an opportunity to serve as tutors or mentor assistants or aides. These student tutors would be paid, and their pay would be based on delivery of help to struggling students as certified by their teachers. Another possible solution was to link math and science grades to level of Science Day participation and judging score. This resulted in the development of a district-wide policy for linking grades to science fair research project participation.

5.1.2 Creating an Academic Environment for More Intensive Research for SEAT Participants

With respect to creating an environment for students to focus on academics and the quality of inquiry-based research projects, TMHS administrators and staff chartered a math and science club for students who prepare inquiry-based research projects and present their project in at least two science fairs. The objectives of the TMHS Science and Math Club are as follows:

- Promote scientific and mathematics enrichment activities that teach problem solving skills focused on the STEM disciplines
- Stretch gifted and talented students in STEM disciplines
- Provide leadership opportunities
- Allow students to compete against the best students from around the state/region in STEM related competitions such as robotics, math, and trebuchet.
- Provide field trips to research career opportunities and work environments in math and science related fields.

In addition to inquiry-based research projects, designated focus areas of robotics, remotely controlled aircraft, academic competitions, rockets, and trebuchet.

6.0 Critical Components of Successful Inquiry-Based Research

6.1 Mentorship

The expected ratio of SEAT researchers to mentors and tutors was to be 10:1 with the right ratio being a function of the defined roles and responsibilities of the mentors and SEAT participant. Mentors were recruited and selected from among the best and brightness from academia. Mentors from both academia and AFRL/RX prepared and provided a list of potential inquiry-based research projects to the TMHS students to research during their summer.

6.1.1 Qualification for Mentors

Primary qualifications considered for the selection of mentors is whether or not there is a willingness by an otherwise technically qualified person to become a Mentor. While many have the technical qualifications to be mentors for science fair projects, unfortunately, many are not willing to do so. Additionally, along with the willingness, an individual must also be patience. So, primary qualifications are having a willingness and patience. Other teachers in the Dayton Public School District should be considered to become SEAT Mentors.

6.2 Math and Science Club Research Activities

A range of physics concepts and theories have been engaged and explored with SEAT Researchers. These concepts and theories include motion in a straight line, laws of motion, equilibrium, gravitation and momentum. Application opportunities for these concepts and theories will be explored, explained and elaborated through the use of Robotics, Rocketry and Remotely Controlled (RC) Aircraft and Vehicles. The Thurgood Marshall Math and Science Club meets every Wednesday at 4:00-5:30 PM in room 1201. The format for every meeting is similar. Prior to Wednesday's Math and Science Club meetings the officers and captains hold a planning meeting to delegate responsibilities and give reports on the upcoming and past events of the club. The club officers and focus team captains were required to attend these meetings. The main purpose of these meetings was to make an agenda for the next club meeting.

6.2.1 Weekly Club Meetings

The president begins each meeting with a call to order and informs all members of the agenda. The secretary of math then reads the minutes from the previous meeting for approval and the president continues on with new business and announcements. Once minutes have been read, captains of each team report to the club. Students usually start off with a math and science problem to get them thinking. The math and science problems used are included in the appropriate overview for the year and science problems are included in Appendix B. The attendance was taken at every meeting by the secretary. The main item of the agenda at Math and Science Club meetings are either a key speaker or a relevant project. Key speakers provide information of math and science and real life applications. The focus of the meetings is based on the activities of the time period. From September through December, most meetings are about the Science Fair with work sessions to help students complete a successful project and periodically presenting their progress and projects to the other members. Students would talk about their projects and mentors would provide feedback. A few mentors that helped include From January until the beginning of April, there was a focus on the Robotics team and preparing a robot to compete in the FIRST Robotics Competition. The months of April and May were dedicated to internal affairs including the election of next year's officers and updating the Club

Charter. Throughout the school year the Math and Science Club went on field trips to places relevant to advancing student interest in the club and STEM applications. Trip reports are included in the appropriate Appendix overview.

7.0 Summary and Recommendations

Noble Solutions recommends continuation of the SEAT Program under a new contract vehicle. This has been a very successful program in offering STEM opportunities to students in a large urban school district. To cite a few examples: The first robotics team captain is now in his second year at Harvard Medical School; the first President of the Math and Science Club established under this contract is now a senior engineering major at the University of Cincinnati (5 year program) after completing his coop program with AFRL/RX this summer; the second President is a senior at Tuskegee with a major in Food Science and interned this summer with Procter and Gamble; the third President is a junior engineering student at the University of Ohio, and interned in the Sensors Directorate for 4 summers; last year's president is attending Wright State University on full scholarship as an engineering major, the current President is returning in the Princeton Leadership summer program that only selects 60 students from across the US. There are numerous other success stories if the 48 SEAT Program students that are just graduating or are currently in college. The latest count is 28 engineering students. One of the key proponents of the program is internships. What we have seen is students participating in internships have all (except one) stayed in college or graduated and most in STEM fields. Many are pursuing STEM or education majors. Also, in the past it has been an incentive and reward for efforts in Inquiry-Based Research Projects. **We recommend a Dayton Public Schools STEM Scholars Program be established for Summer Internships.**

APPENDIX A
Overview of Academic Year 2010-2011
Thurgood Marshall High School Math and Science Club Meetings

The Thurgood Marshall Math and Science Club meets every Wednesday at 4:00-5:30 PM in room 1201 and/or 2211. The format for every meeting is similar. Prior to Wednesday's Math and Science Club meetings the officers and captains hold a planning meeting.

A1. Weekly Planning Meetings:

These are held on Mondays and they are held to delegate responsibilities and give reports on the upcoming and past events of the club. The club officers and focus team captains were required to attend these meetings. The main purpose of these meetings was to make an agenda for the next club meeting, receive updates from each focus team, and air any "dirty laundry" we may have. During these meetings this year, we discussed things like events held at our school sponsored by us, for example, the installation of club officers, the awards ceremony, parents science night, and the coming of Lt. Muckerhide of the AFRL.

A2. Weekly Club Meetings:

The focus of the meetings is based on the activities of the time period. From September through December, most meetings are about the Science Fair with work sessions to help students complete a successful project and periodically presenting their progress and projects to the other members. If we have any new, conditional members, we have introductions and a few activities that allow us to meet and greet. After science fair, which is around January, we try to focus our club meetings on our focus teams and the activities they have coming up. From the start of the school year until March, our club pays much attention to our Academic Quiz Team. Between the months of January and March, our club focuses on Robotics and Chess activities. For the rest of the school year, as it gets warmer outside, our club focuses on Flight and Environmental team activities.

Our club meeting usually work like this: the president begins each meeting with a call to order and informs all members of the agenda. The secretary of science does role call and then the secretary of math reads the minutes from the previous meeting for approval. Next, the president continues on with new business and announcements. Once minutes have been read, captains of each team report to the club. Students usually start off with a math and science problem to get them thinking. Then, we move on to the focus of the meeting which can be a keynote speaker, a debrief from the president, or a fun science lab. Key speakers provide information of math and science and real life applications. Below are a few of the guest speakers we acquired throughout the school year:

A2.1 10/20/10 City of Dayton speaker works along side Rumpke garbage

A Dayton city representative from the Rumpke garbage company came to talk to the members about her job working to prevent the garbage load of recyclables. She explains to the students that when people don't recycle the garbage land fields are left with a bunch of recyclable goods such as plastic bottles and cans. These items will not decompose causing those items to stay for years. She also talks about her job with the city of Dayton water company. Her job includes making sure the water we drink is not full of impure substances such as the garbage that usually stays under ground. Garbage can affect the water supply if the water pump is not

properly secured. She also tells the students how great Dayton city water taste and how they should take back the tap.

A2.2 1/26/11 Todd Rovito's visit

Todd Rovito from the sensors directorate at WPAFB talks to the members about some of their life goals. He explains to the members about his younger years and his dreams of becoming a science fiction character on television. He then showed the members a video of another speaker who had the same bright ideas when he was younger and how he made it a reality but in a realistic way of course. Todd then asks the students about some of their science fiction characters or any other hero they saw themselves being when they got older. He explains how students can become great scientists with hard work dedication and motivation. Todd also gave the members a little history about his experience in high school and college explaining how they differed. In high school he had dreams of becoming an Olympian then when he got to college goals became more complex.

A2.3 2/9/11 Public works speaker Fred Stovall

Fred Stovall talked to the members about how he works in the city to fix some of our city problems. One of those problems is ice storms which happened about a week ago before this meeting. He is responsible for getting some of our pot holes up and bridges fixed that we use everyday. His project at the time was to get all of the left over trees up in the street. The people he works with plan to take the trees and turn them into mulch. He wants to start recycling so it can help the city of Dayton save some money his action was to give some of the members a bin so they could recycle more.

A2.4 2/16/11 Wright State University Team

A Wright State University representative came out to talk to the members and potential careers they saw themselves becoming apart of in the future. She mostly talked about engineering disciplines at how they are amongst one of the highest pay jobs in the industry.

A2.5 3/23/11 Emory Beck-Millerton

Emory Beck is a former Thurgood Marshall student. He was the president of the math and science club for the 2009-2010 year. Emory came back to the club to talk to the members about transferring from high school to college. He explains how more intense college is and how it should be taken serious when you first start. Emory is majoring in mechanical engineering at University of Cincinnati where he is also involved with the Co-op program. University of Cincinnati is well known for its Co-op students and collaborates with big business around the country.

A2.6 3/30/11 Dr. Beck

Dr. Beck is the grandfather of Emory Beck. He came to talk to the members on a more personal level as far as college is concerned. He explained his journey to success and how hard it was to receive his honor. Dr. Beck came from a time where it was hard for African Americans to receive much credit for their hard work. He worked hard every day to earn his engineering degree. He told the students about his ambitions in becoming a football player and how the teacher gave him a failing grade in math because the teacher didn't like the football team. This

nearly effected Mr. Beck engineering degree. Mr. Beck received an Honorary Doctorates degree and is one of the Wright STEPP founders.

On May 19, 2011 Thurgood Marshall Math & Science Club and Air Force Research Lab personnel, led by Colonel Muckerheid and club officers joined together to experience seven educating, interesting hands-on labs most of which involved carbon and its properties and nitrogen both liquid and solid forms.

After a brief PowerPoint on AFRL's bio we split into groups to start the fun labs. At stations 1&2 we were able to make snow with nitrogen and (oobleck) or slime made out of cornstarch and water, we observed that when you pushed your hand in at a fast pace it would act as a solid and when you were to do it slowly it would act as a liquid. Another short demonstration involved a lead and an aluminum ball bouncing in granulated cylinders with a special metallic magnet located in the bottom. Lab 3 gave us an outlook on how carbon is linked with light reflection and camouflage. Lab 4 demonstrated the effects of bubbles when blown into a fish tank that has nitrogen at the bottom. The next lab gave us an opportunity to use sonar and thermal heating. Lab six was a preview of an innovation to army uniform cooling. Last but not least some of our members' favorite lab involving liquid nitrogen, breaking frozen racquet balls in pieces and topping it off with being able to make sorbet after all the hard work was over this lab demonstrated some of the evolution phases without any announcements. Even though AFRL's Dr. Stevens could not attend everyone walked away knowing more about nitrogen, carbon and its many forms/properties, fun facts about science and had a great experience of working with the club. The meeting was adjourned to fruit and veggie trays, cookies, and some sorbet made with blended juicy juice and liquid nitrogen.

A3. Focus Team Activities

A3.1 Environmental Team

This year, the Environmental Team participated in the 2011 ADAPT-A-PARK River clean –up was located at Sun Watch Village. The purpose of his clean up was to enforce the idea of a cleaner environment by picking up the trash located in that park. The environmental team members encountered some unusual objects considered trash. Beer bottles, diapers, milk jugs, and various clothing items. After the cleanup, we were invited to a picnic at East Park. The Environmental Team members had a great time and will continue the tradition in participating in the annual ADAPT-A-PARK River clean up!

A3.2 Trebuchet Team

This, year, the Trebuchet team participated in their first annual trebuchet competition was held at the Wright State Nutter Center. We competed in one match against a team that had been doing the competitions for a while. Although we lost our match we learned and saw what we did wrong. While we were there we saw the other different types of trebuchet designs that other teams had. We also ran through a few ideas for next year's competition.

A3.3 Flight Team

This year, our Flight Team held its every own fly-inn, which is designed to embrace the adventures of remote control aircraft during the winter. We had about a dozen planes flying through our school's gym and we also had a flight simulator set up. Many people came to support and overall it was fun seeing others learn how to fly an R.C. airplane. Next, we will be working on our outdoor flying days throughout the summer and through the fall season.

A3.4 Robotics Team

The robotics build season began January 8, 2011, with the kickoff and announcement of this year's game from First robotics. The robotics team would meet every day Monday – Friday from 4:00 P.M. – 7:00 P.M, sometimes later, and occasionally on weekends. Their task was to build a robot that could play a game called "Logomotion", where the robot must be able to place logo shapes onto poles, as well as creating a mini-bot that must be able to climb approximately an 11 foot pole in a matter of seconds. The team received help from mentors that came out from Booz-Allen-Hamilton, Wright-Patterson Air Force Base, and Brainerd Industries. Throughout the build season, the robotics team captain, Chris Ray, would keep the general body of the club updated on the progress of the robot.

A3.5 Academic Quiz Team

For the 2010-2011 school year, the Math and Science Club brought something new to its members and a few other students in the community that we combined with our Academic Quiz Team. This year, the students took part in a new event called Try-Math-a-Lon, also known as T-mal. This program is designed to increase the students' Math SAT and ACT scores by bringing in mentors with STEM backgrounds not only from the Air Force Research Lab, but also form the surrounding universities like Wright State and University of Dayton. T-mal is also a fun competition! Every other Saturday morning of the month between September-March, the students would gather at Thurgood Marshall High School; ready to be enriched for our standardized tests as well as one of our upcoming competitions. Not only did our club members take home 1st and 2nd place at the local competition, but we also received the chance to compete in the regional competition in Indianapolis, Indiana. The T-mal program has also done about for our students' test scores; proving that the program has raised students' Math ACT scores by an average of three points.

A4 Club Field Trips

Throughout the school year the Math and Science Club went on field trips to places relevant to advancing student interest in the club and STEM applications. These trips included:
FIRST Robotics Buckeye Competition: The robotics build season wrapped up with the trip to the Buckeye Regionals in Cleveland, OH held April 6-9, 2011. Within the Regionals competition, the robot incurred multiple issues. As soon as one issue was dealt with, another one had to be addressed. This process carried on until the final few matches of the competition. By the time all the kinks were worked out, the competition was practically over. This resulted in the season being declared "Unsuccessful", with the blame going towards the robotics team members' lack of commitment. However, this season is a lesson that is to be learned from, and the robotics team is sure to try harder and show more commitment next year.
NASA Glenn Research Center: At the beginning of this year both the Rocketry and R/C Aircraft team sponsored the NASA Glenn trip held in Cleveland, OH; on Thursday September 23,2O10. The students went to the Great Lakes Science center where their memory was refreshed on Newton laws. On Friday, the students gained a lot of information about different Aircrafts used by NASA. They also had a chance to walk around the hanger where most of the work is done. The students were also engaged in a friendly activity that dealt with force, pull, drag and gravity, learning that less is more when an aircraft is built because gravity and drag play a big part. An aircraft can't have a lot of weight because gravity will pull it done which doesn't make a lot of sense when you are trying to fly in the air.

NSBE Region 4 Conference: This year the Thurgood Marshall high school math and science club added a new collaborating activity, The National Society of Black Engineers (NSBE). Our math and science club chartered our very own NSBE Jr. Chapter, being the very only in the district with a highly active chapter. From November 19, 2010 through November 20, 2010 we were able to participate in a regional conference where we competed in a friendly competition called T-MAL (try-math-a-lon). This was a wonderful experience where we were able to network and mingle among other high school students like us. In addition to high school students we were also able to meet engineering professionals who are very well off and distinguished individuals. When first arriving, our group of students participated in a Tour of Indiana University - Purdue University Indianapolis. The tour of IUPUI was a STEM focused campus tour. Students were exposed mainly to the Purdue School of Engineering and Technology and the Purdue School of Science located on IUPUI's campus. The students were able to see the labs and facilities within the schools. Hands on activities were incorporated as well. The students also had the opportunity to interact with the IUPUI faculty and staff and current students. Marshall Students competed against other students in the TMAL competition engaging in individual and group efforts. While there, there was participation in seminars and also networking with engineering professionals. The following day there was a dinner and awards banquet. Thurgood Marshall departed for Dayton on November 20, 2010.

A5. Science Fair Cycle and Awards

Every year, any student who wishes to be in our club must participate in the school science fair. At the school science fair, we had a great number of participants. And the Dayton District Science Fair, we had the largest number of students from any high school there and also conquered awards from every category. For the West District Science Fair, our club took about 35 students and the awards that our school took home are listed below.

A5.1 Individual Superior Projects

- Tyler Bocock 12th Grade T. Marshall “Sol-Gel Fuel Cells”
- Leah Freeman 12th Grade T. Marshall “Music Stimulates Children”
- Desmond Dixon 12th Grade T. Marshall “Relating Rubber Muscle Actuator with Micro Air Vehicle Development”
- Myisha Slade 12th Grade T. Marshall “Wind Turbines and Energy”
- Eugene Whatley 12th Grade T. Marshall “Acceleration of Battery-Powered cars on Different Surfaces”
- Jhaelynn Elam 12th grade T. Marshall “Preventing Aircraft Failure through Insulation Testing”
- Asia Ray 11th Grade T. Marshall “At the Speed of Sound”
- Brittany Davis-Rowe 11th Grade T. Marshall “The Energy given off in a Combustible Reaction”

A5.2 Alternates

- Takeisha Hankins 11th Grade t. Marshall “DNA Salmon Sperm Cell Processing”
- Tiarra Hayes 11th Grade T. Marshall “The Power Grid”

A5.3 U.S. Air Force Regional Science Fair Award:

- Eliza Straughter 11th Grade T. Marshall

A5.4 US Army Award:

- Myisha Slade 12th Grade T. Marshall
- Takeisha Hankins 11th Grade T. Marshall
- Tyler Bocock 12th Grade T. Marshall

A5.5 Office of Naval Research Naval Science Award:

- Donovan Davis and Zavan Blount-Hill (team) 12th Grade T. Marshall

A5.6 Central State University Scholarship (Majoring in Engineering):

- Myisha Slade 12th Grade T. Marshall
- Donovan Davis and Zavan Blount-Hill (team) 12th Grade t. Marshall
- Jhaelynn Elam 12th Grade T. Marshall
- India Ray 11th Grade T. Marshall

A5.7 Dayton Advocates for Computing Women:

- Eliza Straughter 11th Grade T. Marshall
- Jasmin Sanford 9th Grade T. Marshall

A5.8 ASM Materials Education Foundation and Institute of Environmental Sciences and Technology:

- Jhaelynn Elam 12th Grade T. Marshall

A5.9 Charanjit Rangi Memorial Award in Mathematics:

- Brittany Davis-Rowe 11th Grade T. Marshall

A5.10 CSU Women and Minorities Award:

- Brittany Davis-Rowe 11th Grade T. Marshall
- Kendrey White 9th Grade T. Marshall
- Chelsea Woods 12th Grade T. Marshall

A5.11 Thyrsa Svager Memorial Award in Mathematics:

- Kadijah Taylor 9th Grade T. Marshall

A6. Election of Officers:

During the months of March and April, the club focused on wrapping up the school year and handling internal affairs. Meetings tended to focus on the following year with ideas for the next year's science fair and ways to research and get ready; elections for officers began with information being provided on how elections will take place and the announcement of presidential candidates. Those candidates were Eliza Straughter and Takeisha Hankins. At some meetings, students played games provided by other students, these games were usually science or math themed. Once everything came to an end, snacks were served and the president adjourned the meeting. The two went back and forth through the month of March and at the start of April,

the entire club voted on who would be there 2011-2012 Club Presidents. The club elected Eliza Straughter, and by default, Takeisha Hankins took on the position of Vice President of Science.

A6.1 Club Charter Modifications:

The Math and Science Club made some changes to their charter in order to make the club run more smoothly. The charter is similar to the constitution in that it is a living document, changes were made on subjects that were not specified or mention that sometimes made running the club harder. The following changes to the Math and Science Club Charter:

- Changing the year from 2009 - 2010 to 2010 – 2011
- Because of previous year mishaps, the Vice President of Science will preside over the Robotics Team and will act as a team captain. This person cannot be a winter sport participant, have any leadership in any other organization, and must be fully dedicated to the team.
- The Vice President of Math presides over all other focus teams inside the club like AQT, Flight, Environmental, etc.
- As of this school year, the club will not openly accept any new Seniors into the club. In order to be a senior in the club, the person must have been in the club as a junior. If there is a senior wishing to be a new club member, they must take this up with Mr. Noble go through a legit process.
- At every Wednesday club meeting, all club officers must wear a club shirt. Other team captains, mentors, and members must wear a club shirt at least twice a month.

A7. 2010-2011 Math and Science Trivia

1. What is the difference between a new penny and an old quarter?
    a. 24 cents
2. If you can buy eight eggs for 26 cents, how many can you buy for a cent and a quarter?
    a. 8.
3. How many times can you subtract 6 from 30?
    a. Once; after that, it's no longer 30.
4. Which weighs more? A pound of iron or a pound of feathers?
    a. They both weight the same.
5. The REAL Math Question: Which of these is one of the factors of the expression $4x^2 - 25$?
    a. $(4x - 5)$
    b. $(4x + 5)$
    c. $(2x + 5)$
    d. $(4x - 25)$

1.3a + b = 11. What is the value of 9a + 3b?
Answer: 33
(9a + 3b) can be rewritten as (3)(3a + b).
3×11 = 33.

Science Question
2. Why is solid copper wire a good conductor?
Answer: Because the electrons move easily within the wire. The outer electrons of the atoms of metals, such as copper, are weakly held to the atomic nucleus. When a voltage

is applied to a metal wire, these electrons will move through the wire. This movement of electrons is a flow of charge, or electrical conductivity. If electrons flow easily through the wire, then the metal is a good conductor.

APPENDIX B
Research Projects Academic Year 2010-2011
B1. Primary Colors to the Human Eye – DeMarria Moss, 11th Grade, Thurgood Marshall High School

B1.1 Abstract
The purpose of my project was to determine light intensity levels. The three colors of light that were tested, known as primary colors, were compared to the white light. White light has a very high intensity level. White light is a mixture of colors of the visible spectrum. Once conducting my experiment, I was able to test the primary colors of lights which are red, green and blue. Each color contains an certain amount of energy known, as photons that is needed to be produced. From there I started to test the brightness of each color. Once more voltage is applied the brighter or darker that color gets.

B1.2 Introduction
If you pass white light through different color filters, then the red would be the brightest because red has the longest wavelength.

The color of an object depends on both the physics of that certain object in its environment and the characteristics of the perceiving eyes and brain is the Color Theory.

Color deficiency known as color blindness refers to the inability of a person to distinguish certain colors, or maybe not seeing that certain color of the environment. There are many ways people can be effected especially having a illness of some kind for example, having diabetes, macular degeneration, glaucoma, The Alzheimer disease, sickle cell, aging, side effects of certain medications and or chemical exposure. Mostly males are affected.

The causes of colorblindness, are because of the cells in the retina doesn't process that color correctly. Photoreceptors cells are located in the retina of the eye, which function best in relatively bright light. When light enters the eyes, it forms an image on the retina. On the back part of the eyeball, it is composed of three layers. The first layer contain 125 million photoreceptors called rods and cones, they both receive light signal. The second layer contain bipolar neurons with synapses for connection with the third layer. And lastly the third layer has a ganglin cell with dendrites in contact with optic nerve, which travels information to the brain. In the retina it has a variety of light sensing cells known as rods and cones. Rod are sensitive to the intensity of light, they cannot distinguish between lights of different wavelengths. Cones are the color-sensing cells of the retina these cones are responsible for the color vision that sends the wrong signal to the brain. The human vision is based on the absorption of light by the photoreceptor cells are sensitive to light in two relatively narrow region of the electromagnetic spectrum. In 1850, Helmholtz Theory provides that there are three photoreceptors known as cone cells in the eyes. The photoreceptors range from short, middle, and long.

The primary colors are red, yellow, and blue. These colors can be combined to make a useful range of colors. Red, Green and Blue are normally the primary color for light and fundamental to the human vision system. In the Trichromatic theory of color vision, it explains that there are three receptors in the retina that are responsible for perception of color. One receptor is sensitive to the colors green, red and blue.

The electromagnetic spectrum is a wave that consists of an electric field.

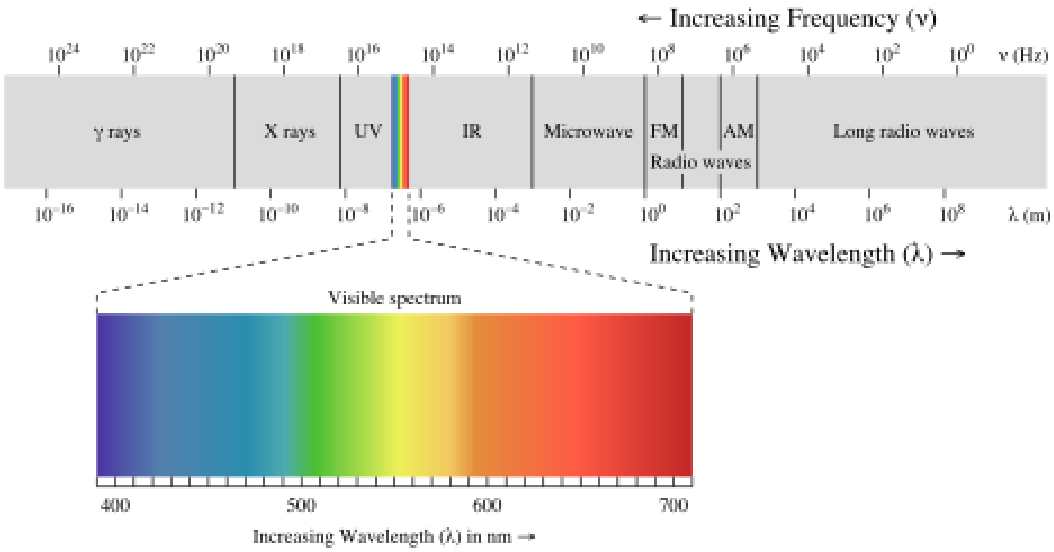

Figure B-1. Electromagnetic Spectrum

Electromagnetic radiation is always known as photons. Photons travel in a wave-like pattern and moves at the speed of light. Each photons contains a certain amount of energy. Electromagnetic radiation is made up of these photons. Light is known as optical light which is the radiation visible to the human eye. Visible light is called electromagnetic spectrum. The electromagnetic spectrum can be broken down into: gamma- rays, X-rays, ultraviolet, optical, radio, and infrared. All that was listed are called light. Part of the Electromagnetic spectrum is the visible spectrum which is visible to the human eye. The electromagnetic range has wavelengths from about 390mn to 750nm at light adaptation. In the visible spectrum, the visible spectrum is a range of rainbow colors that the human eye can perceive. Red, orange, yellow green, blue, indigo, and violet. These colors that are listed are part of the visible spectrum of light.

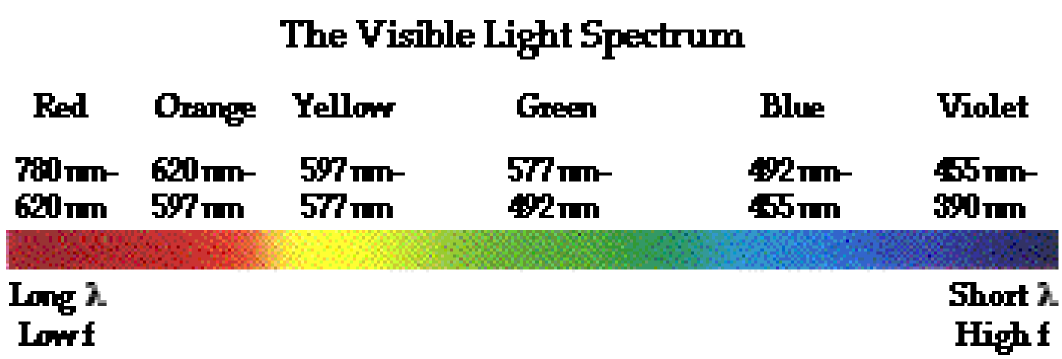

Figure B-2 Visible Light Spectrum

Red has a wavelength of 650 nm, orange 590 nm, yellow 570 nm, green 510 nm, blue 475 nm, indigo 445 nm, and violet 400 nm. These colors are known as spectral color because every wavelength of light is perceived as a spectral color. Typically a human eye will respond to wavelengths from about 390 to 750 nm. As well the human eye has a maximum sensitivity level at 555 nm. The equation for wavelength: speed/frequency. Example: If red and green cone cells are stimulated through yellow light having a wavelength of 580 nm, the cone cell receptors each

respond almost equally because their absorption spectral overlap is approximately the same in the same in this region of visible light spectrum.

B1.3 Methods

1. This project has to be done in a dark room.
2. You will measure the light intensity in the room with no light. This is necessary to have to receive accurate measurement.
3. Turn the supply up to one volt. Record the voltage amperage.
4. Measure the light intensity of the white light bulb.
5. Pass the light through a red filter. Measure the light intensity.
6. Pass the light through a blue filter. Measure the light intensity.
7. Pass the light through a green filter. Measure the light intensity.
8. Repeat steps 3-6 for 2v, 3v, 4v and 5v.

B1.4 Materials

- DC regulated Power Supply
- Light Sensor
- A Computer
- 10 watts light bulb
- Red/Blue/ Green colored filter.

B1.5. Results

Table B-1 Experiment Results

Volatage	White light intensity	Red light intensity	Green light intensity	Blue light intensity
1v	2.2 lx	2.2 lx	2.2 lx	2.2 lx
2v	24.0 lx	3.0 lx	5.5 lx	5.0 lx
3v	421.0 lx	186.0 lx	128.6 lx	97.0 lx
4v	770.0 lx	535.6 lx	372.0 lx	192.0 lx
5v	770.0 lx	764.0 lx	430.0 lx	647.0 lx

*2.2 Lux in room this will be subtracted from everything to give all measurement the same base line

B1.6. Discussion

In this experiment I used measurement of voltage, amperage and lumens. Amperage is a measure of the amount of electrons moving in a circuit. Voltage is how much force those electrons are under.

Once I tested my hypothesis, the results came out how I expected. The red light intensity level was the brightest because the color red is the longest wavelength in the visible light spectrum. This is because the less energy a wave carries the longer the wavelength is. This is because red carries the least energy of all the colors in the visible spectrum. Many items, such as street signs are green because it’s easier to see that color.

B1.7. References

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B2. Sol Gel Fuel Cells, Tyler Bocock, Grade 12

B2.1 Introduction

In doing my project my task was to try and create an ionic compound that can withhold an electrical current at high and low temperatures. Since I was working at Wright Patterson Air Force Base I was working to enhance the technology for our war fighters. To place this idea into application if you were to think about a lap top, the average battery of a laptop has a life span 4 to 6 hours after being fully charged. Creating these anode materials will increase the lives of these batteries and will allow the laptop to be revised and made smaller and more compact.

B2.2 Sol-Gel Fuel Cells

B2.2.1 Objective/ Goal:

My goal for this project is to try and make a better anode material for solid oxide fuel cells. The first law of thermal thermodynamics, which mandates conservation of energy, and states in particular that the flow of heat is a form of energy transfer.

B2.2.2 Hypothesis

Based on this I hypothesize that if doping the cells with different metallic compounds (anode ink pastes), then creating oxygen vacancies will allow us to increase conductivity because hydrogen now has the chance to react with the oxygen in the pours layer of the ink paste.

B2.2.3 Background

Solid oxide fuel cells (SOFCs) use a hard, nonporous ceramic compound as the electrolyte. Because the electrolyte is a solid, the cells do not have to be constructed in the plate-like configuration typical of other fuel cells types. SOFCs are expected to be around 50 to 60 percent efficient at converting fuel to electricity. In applications designed to capture and utilize the system's waste heat (co-generation), overall fuel use efficiencies could top 80%–85%.

(LDC) between the anode and the electrolyte was used to prevent interdiffusion of ionic species between SMMO (strontium, magnesium, molly, oxygen) and LSGM (lanthanum, strontium, gallium, magnesium) with a chemical composition of 18–20. SOFCs are also the most sulfur-resistant fuel cell type; they can tolerate several orders of magnitude more of sulfur than other cell types. SOFCs operate at very high temperatures around 1,000 °C (1,830 °F). High-temperature operation removes the need for precious-metal catalyst, thereby reducing cost. It also allows SOFCs to reform fuels internally, which enables the use of a variety of fuels and reduces the cost associated with adding a reformer to the system. Barriers to the introduction of hydrogen as the fuel have stimulated interest in developing an anode material that can be used with natural gas under operating temperatures 650 °C < T < 1,000 °C. Here identification of the double perovskites $Sr_2Mg_{1-x}Mn_xMoO_{6-\delta}$ meets the requirements for long-term stability with tolerance to sulfur and show a superior single-cell performance in hydrogen and methane.

Generally speaking, there are a number of possibilities to measure thermal conductivity, each of them suitable for a limited range of materials, depending on the thermal properties and the medium temperature. A distinction may be observed between steady-state and transient techniques. In physics, thermal conductivity, k, is the property of a material that indicates its ability to conduct heat. It appears primarily in Fourier's Law for heat conduction. Thermal conductivity is measured in watts per kelvin per metre ($W \cdot K^{-1} \cdot m^{-1}$). Multiplied by a temperature difference (in kelvins, K) and an area (in square metres, m^2), and divided by a thickness (in metres, m) the thermal conductivity predicts the rate of energy loss (in watts, W)

through a piece of material. The first law of thermodynamics is an expression of the principle of conservation of energy. The law expresses that energy can be transformed, i.e. changed from one form to another, but cannot be created or destroyed. It is usually formulated by stating that the change in the internal energy of a system is equal to the amount of heat supplied to the system, minus the amount of work performed by the system on its surroundings. Work and heat are due to processes which add or subtract energy, while U is a particular form of energy associated with the system. Thus the term heat for δQ means that amount of energy added as the result of heating, rather than referring to a particular form of energy. Likewise, work energy for δw means "that amount of energy lost as the result of work". Internal energy is a property of the system whereas work done and heat supplied are not. A significant result of this distinction is that a given internal energy change (dU) can be achieved by, in principle, many combinations of heat and work.

$$dU = \delta Q - \delta W$$

"Formula to find amount of internal energy"

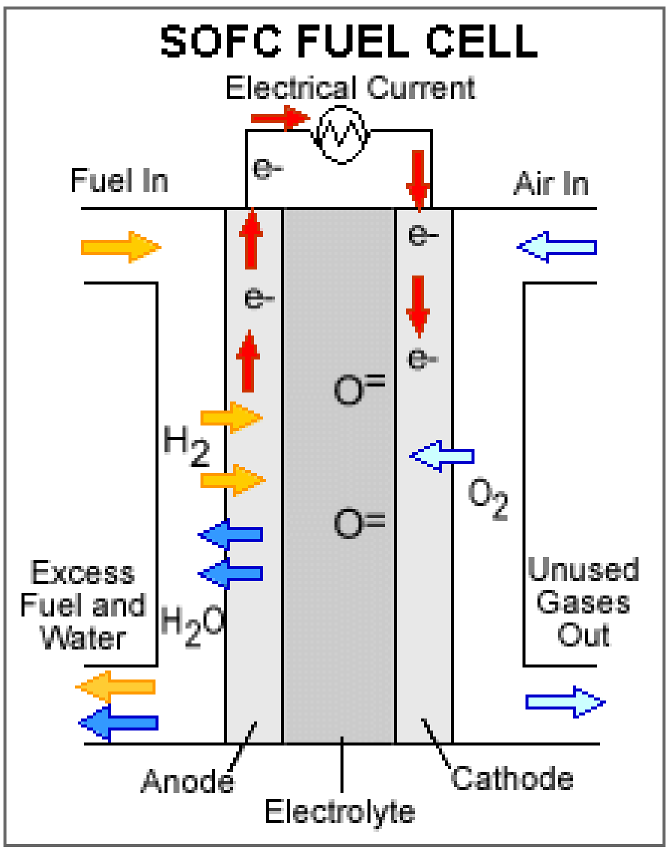

Figure B-3 SOFC Fuel Cell

An SOFC consists of a nonporous metal oxide electrolyte (typically zirconium oxide) sandwiched between an anode (negatively charged electrode) and a cathode (positively charged electrode). The processes that take place in the fuel cell are as follows: 1. Hydrogen fuel is channeled through field flow plates to the anode on one side of the fuel cell, while oxygen from

the air is channeled to the cathode on the other side of the cell. 2. At the cathode, a catalyst causes electrons from the electrical circuit to combine with oxygen to create negatively charged oxygen ions. 3. The negatively charged oxygen ions flow through the electrolyte to the anode. 4. At the anode, the catalyst causes the hydrogen to react with the oxygen ions forming water and free electrons. 5. The negatively charged electrons cannot flow through the electrolyte to reach the positively charged cathode, so they must flow through an external circuit, forming an electrical current. 6. At the cathode, the electrons combine with oxygen to create negatively charged oxygen ions, and the process repeats.

B2.2.4 Procedures

Step 1- Do the molarity calculations for the solution that will be used.

Step 2- Now for sol-gel to take place you must combined you chemicals into a Pyrex 5000ml beaker and place on a hot plate at 400* with a stir magnetic stir bar so that the materials used stay in solution. (If the solution gets cloudy add some nitric acid until it is back down in pH and is back clear).

Step 3- Wait until the solution fully combust. If you pay attention to the solution depending on your solution time may vary but before it's ready to combust the solution will be a gel. Then the solution will catch fire and produce ash.

*Caution- The pot will be hot so make sure you turn off the hot plate and wait till the beaker has had time to cool.

Step 4- After the beaker has cooled collect all of you ash inside of the beaker. Some of the ash might have slipped out of the beaker but don't worry that stuff may be contaminated if it came out just clean it up and throw away.

Step 5- Place you materials inside of a hot box or a furnace for 24 hours at 800* Celsius to sinter the material so that it all is combusted and as pure as it can get.

Step 6- After you powders have been sintered press them into pellets shapes do not matter just as long as you have a nice surface area were you will be able to paste you anode and you cathode on each side along with you leads for you conductivity testing.

Step 7- When you cell is fully developed and ready for conductivity testing load it up and run your tests. (I used a solartron machine, specifically designed for this).

*Be sure to record you results so you will have data to look at. I specifically went from 800*c to 400*c running a test after every 25 degrees. The tube furnace was programmed so that the furnace would decrease 1 degree in every 2 minutes. So patience is the key when conducting such a high profile test.

B2.2.5 Results

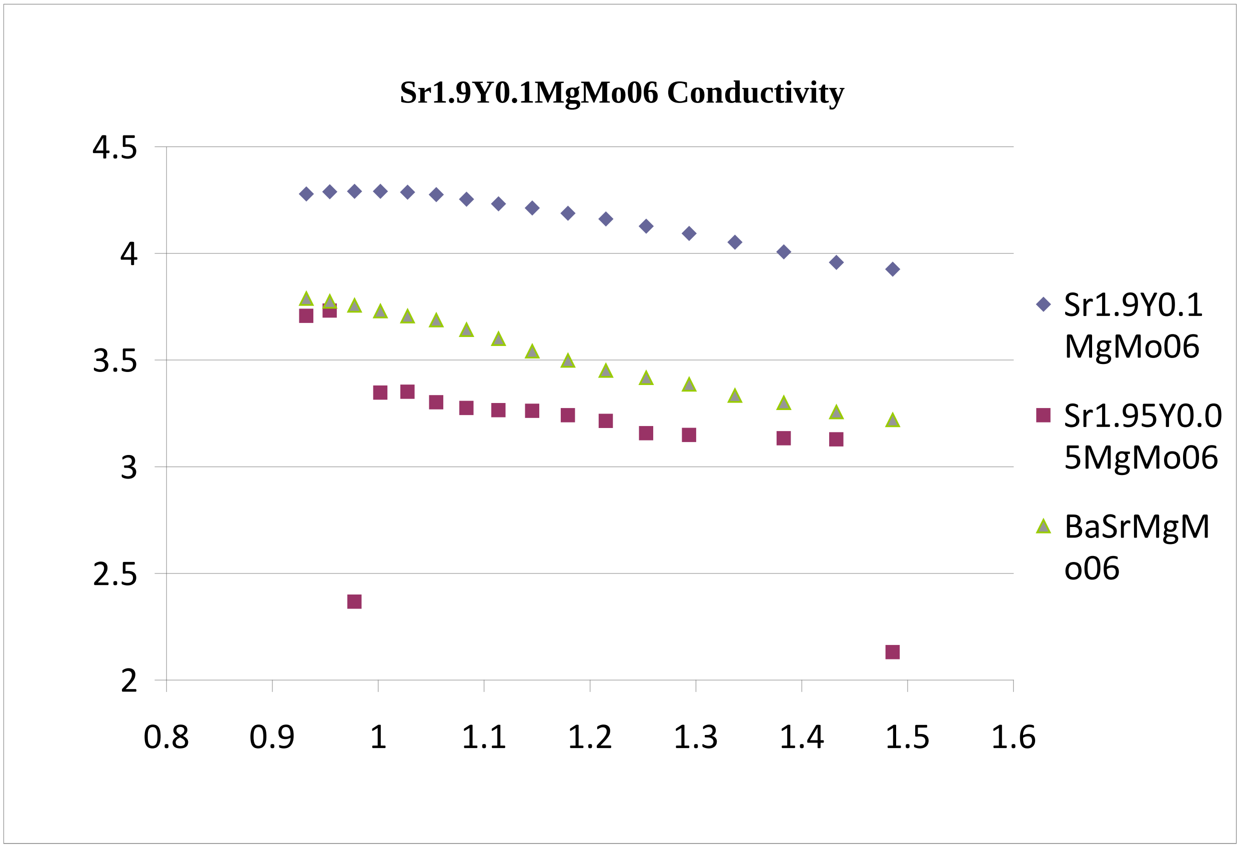

Figure B-4 Conductivity Testing of the Metallic Compounds

This chart shows conductivity testing of the metallic compounds created. Strontium 1.9, the blue diamond line shows the highest amount of electrical current. It also shows to have the least amount of draw which means it is the most conductive of the three compounds tested.

B2.3 References:

Milewski J, Miller A. (2006). "Influences of The Type and Thickness of Electrolyte on Solid Oxide Fuel Cell Hybrid System Performance". *Journal of Fuel Cell Science and Technology* **3** (4): 396–402.
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B3. Applicability of Wire Abrasion Through Insulation Testing

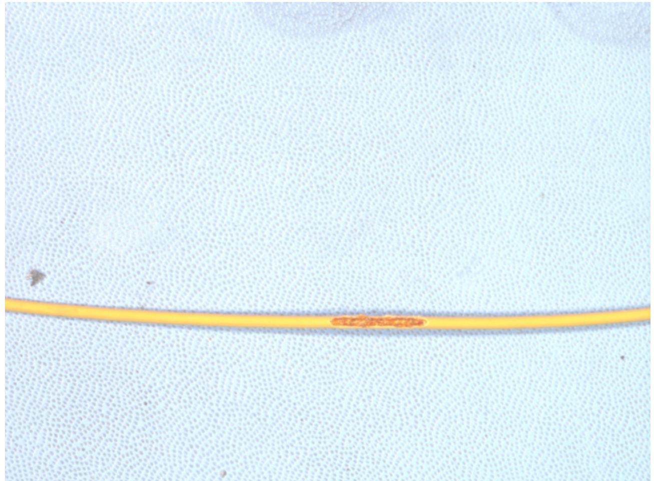

Figure B-5 Wire Abrasion and Insulation

Jhaelynn Elam, 12th Grade, Thurgood Marshall High School

B3.1 Abstract

The purpose of the testing was to determine whether or not a wire abrader is accurate in testing the abrasion resistance of different aircraft wire insulations. In the beginning a decision had to be made on the test variables and wire insulation types to test. The types of insulation chosen were polyimide tapes, XL-ETFE, PTFE, and ETFE. Each type of insulation has different properties and are most applicable in different environments. Test were also conducted adjusting these variables: Weight (600 g, 400 g, 200 g) Resistance (10 N, 12 N, 16 N) Needle variation (cleaned, new, old). Once baseline test was complete, another test of error was initiated using weight of 800g400g, needles variation of New and Old needle and a resistance of 10N and 15N. In conclusion I determined that the wire abrader was an inaccurate test and the insulation that was most resistant to abrasion was the Teflon.

B3.2 Introduction

Over the past summer I participated in an internship at the Wright Patterson Air Force Base. I was assigned to work at the materials and manufacturing directorate with the electronic failure analysis team. One of the primary goals of this section is conducting Mishap Investigations. A mishap investigation takes place when an aircraft goes down. This team of electrical engineers and experts are then assigned to the task of determining what happened. Mishap description and investigational procedures play a key role in understanding what areas failed in the accident sequence of events and provides us the correct tools to address appropriate. Recommendations, in order to prevent future similar situations that lead to incidents or accidents. The investigation of and aircraft accident is always a difficult task, in where a great number of factors might be involved and where sometimes part of the clues are hidden or missing. It is like an enormous puzzle where we have to engage all the pieces according to the info provided by, engines, cell, avionics, forensic, human factors etc..., but we have very often a big challenge, some of the pieces of the puzzle are missing, deteriorated, bleached, burned, or even artificially misplaced, and we have to figure out what are they and where to fit them. Mishap investigation

is one of the fundamental tools to ensure a safe and healthful working environment for military and civilian personnel. Mishap records and reports are required by Federal law and provide information to identify unsafe acts and conditions and to apply corrective or preventive measures to preclude recurrence.

B3.3 Background Information

Within aircraft there are a number of factors that may result in aircraft failure. One particular common cause is internal damage to aircraft wiring. Wire may rub against one another or simply begin to decay. There are a variety of aircraft insulations that withstand certain environments better than others.

B3.3.1 Kapton

Kapton is a polyimide film developed by DuPont which can remain stable in a wide range of temperatures, from -273 to +400 °C (0 – 673 K).[1] Kapton is used in, among other things, flexible printed circuits (flexible electronics) and thermal micrometeoroid garments, the outside layer of space suits.

The chemical name for Kapton K and HN is poly(4,4'-oxydiphenylene-pyromellitimide). It is produced from the condensation of pyromellitic dianhydride and 4,4'-oxydiphenylamine. Kapton synthesis is an example of the use of a dianhydride in step polymerization. The intermediate polymer, known as a "poly(amic acid)," is soluble because of strong hydrogen bonds to the polar solvents usually employed in the reaction. The ring closure is carried out at high temperatures (200–300 °C, 473-573 K).

B3.3.2 Teflon

PTFE is a synthetic fluoropolymer of tetrafluoroethylene that finds numerous applications. PTFE is most well known by the DuPont brand name Teflon.

PTFE is a fluorocarbon solid, as it is a high-molecular-weight compound consisting wholly of carbon and fluorine. Neither water and water-containing substances nor oil and oil-containing substances are wet by PTFE, as fluorocarbons demonstrate mitigated London dispersion forces due to the high electro negativity of fluorine. PTFE has one of the lowest coefficients of friction against any solid.

PTFE is used as a non-stick coating for pans and other cookware. It is very non-reactive, partly because of the strength of carbon–fluorine bonds, and so it is often used in containers and pipework for reactive and corrosive chemicals. Where used as a lubricant, PTFE reduces friction, wear, and energy consumption of machinery.

B3.3.3 Cross Link ETFE

Cross link ETFE are bonds that link one polymer chain to another. They can be covalent bonds or ionic bonds. Polymer chains can refer to synthetic polymers or natural polymers (such as proteins). When the term "cross-linking" is used in the synthetic polymer science field, it usually refers to the use of cross-links to promote a difference in the polymers' physical properties. When crosslinking is used in the biological milieu, it refers to use of a probe to link proteins together to check protein-protein interactions, as well as other creative cross-linking methodologies.

Tefzel® is a modified ETFE (ethylene-tetrafluoroethylene) fluoropolymer availableas pellets or as powder for rotational molding. Tefzel® combines superior mechanical toughness with an outstanding chemical inertness that approaches that of Teflon® fluoropolymer resins.

Tefzel® features easy processibility, a specific gravity of 1.7, and high-energy radiation resistance. Most grades are rated for continuous exposure at 150 °C (302 °F), based on the 20,000-hr criterion.

B3.4 Statement of Problem

My goal is to examine those who may be most resistant to abrasion. While doing so I plan to determine is a wire abrader an accurate method for testing the durability of aircraft wires? If so which wire insulation is most resistant to abrasion?

B3.5 Hypothesis

If old needles are used in the experimentation then the wire abrader will reveal inconsisrent results; exposing the kapton insulation as most abrasion resistant because of research and direct experience with polyimide tapes the insulation will begin to build on the needle creating a slippery consistency that will make it harder to abrade through the wire insulation.

B3.6 Procedure

B3.6.1 Baseline Testing

Step 1.Cut strand of wire
Step 2. Using a wire stripper strip off the insulation
Step 3.Change needle if necessary
Step4.Connect the stripped end to the stopping mechanism
Step 5.Using the digital force gauge measure resistance
Step 6.Add weight
Step 7.Immediately screw down the wire to specified tension
Step 8.Set the counter to zero
Step9.Turn on the abrader and check periodically while documenting all observations.
Step 10.Repeat steps 1-8 once again for accuracy testing
Step 11.Calculate error percentage between the two trials.

B3.6.2 Error testing

Step 1.Cut strand of wire
Step 2.Using a wire stripper strip off the insulation
Step 3.Change needle if necessary
Step 4.Connect the stripped end to the stopping mechanism
Step 5.Using the digital force gauge measure resistance
Step 6.Add weight
Step 7.Immediately Screw down the wire to preferred resistance
Step 8.Make sure the counter is set to 0
Step 9. Turn on the abrader and check periodically to document all observations

B3.6.3 Data Analysis

Step 1.Graph each set of data
Step 2.Calculate error percentage
Step 3.Compare Trials

Step 4.Review Hypothesis
Step 5.Graph error percentage
Step 6.Review Kapton vs. Teflon
Step 7. Review Old vs. New needles
Step 8. Review 15N vs. 10N
Step 9. Review 400g vs. 800g
Step 10. Graph, record, document data

B3.7 Materials

Wellman repeated scrape abrasion tester
Wire Stripper/Cutter –Reflex T-Stripper
Digital Force Gauge
Models DFG-100, DFGHS10

4 types of Wires with different insulation materials

- M81381/11-20
- M22759/18-18
- M22759/11-20
- M22759/44-20

Needles- M101008

Weights

- 200g
- 400g
- 600g

B3.8 Technical Discussion

In my results I found that the Teflon insulation was the toughest to abrade through, therefore was the most durable and abrasion resistant. In testing with the wire abrader I noticed my results weren't consistent. The data had sporadically increases as well as decreases.
I also noticed my variables affected the data tremendously. A pattern was created and each set of data displayed a different one.

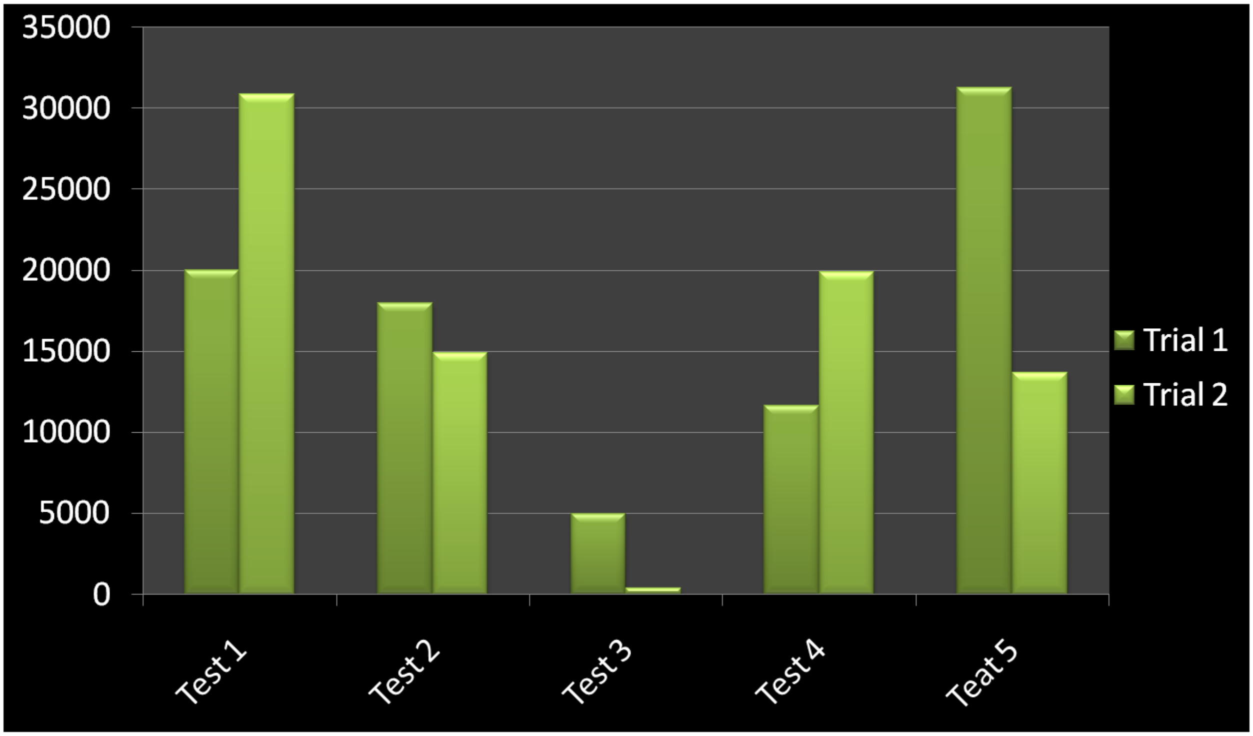

Figure B-6. PTFE

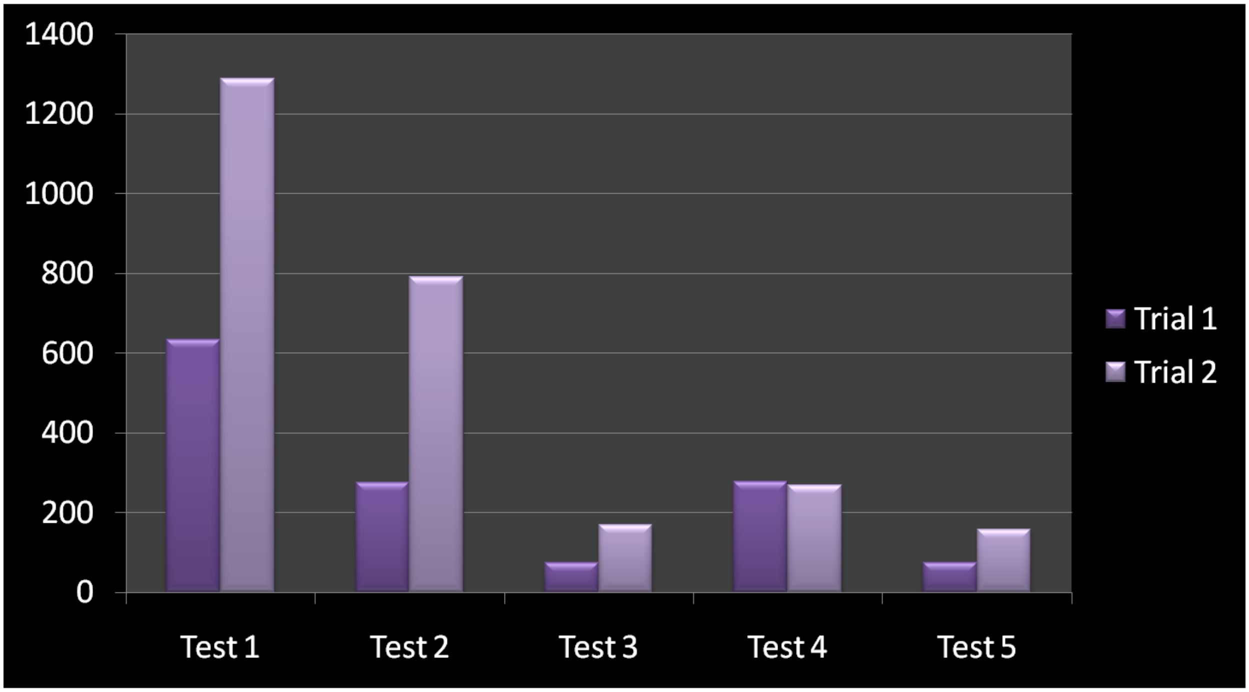

Figure B-7 XLETFE

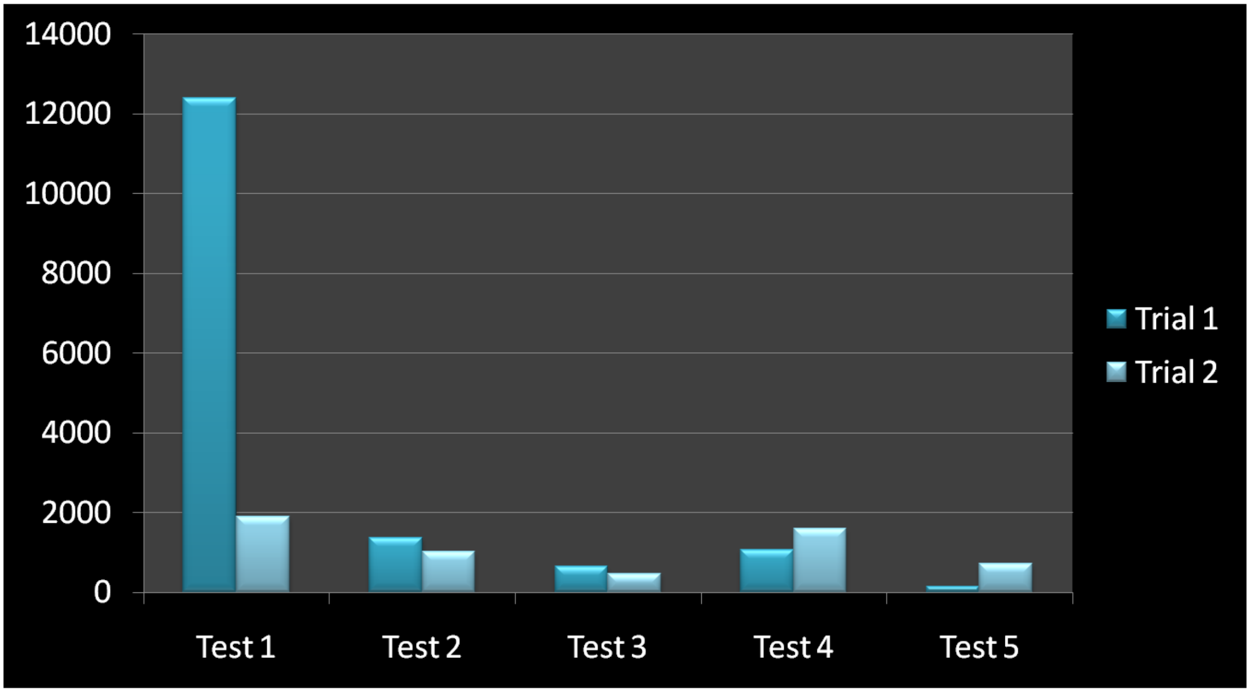

Figure B-8 ETFE

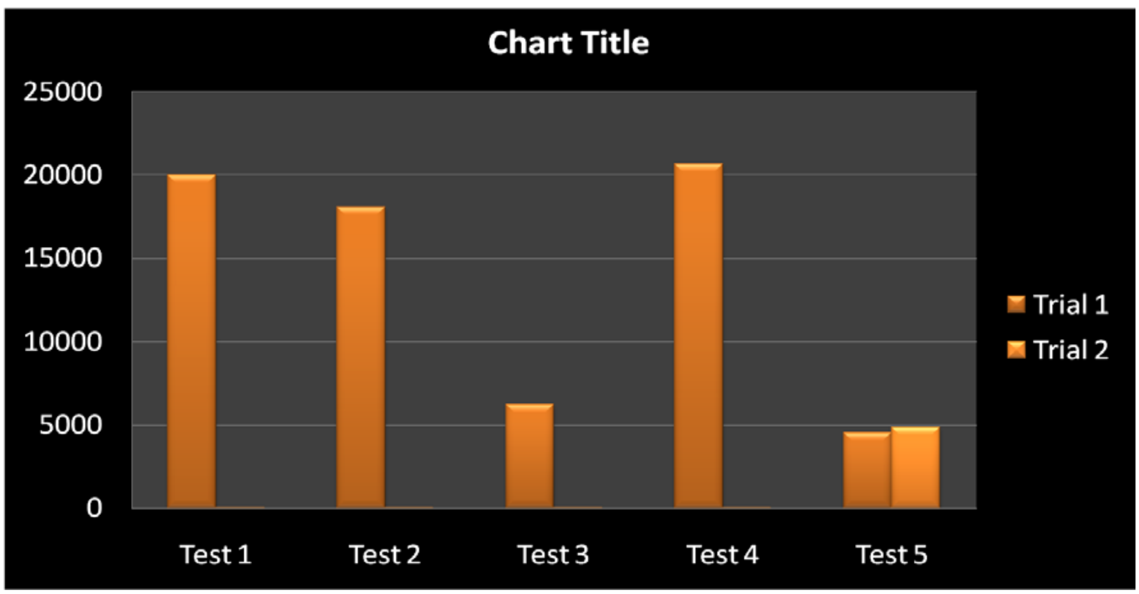

Figure B-9 Kapton

B3.9 Conclusion

In conclusion, I have determined for further testing a new test must be used in order to have accurate data. There should be utilization of a new test called a wire-to-wire test. In this testing the process Is more realistic in which it uses two wire who rid each other of their insulation. This process more truly exemplifies what goes on inside the aircraft. The variables that were used were of standard testing and were accurate in weeding out error. The data reveals that as an old needle is used the consistency of the data decreases. It is clear that a new needle must be used in order to obtain accurate data.

B3.10 Acknowledgements

Air force research labs; Materials and Manufacturing directorate
Daniel Adducchio and the electronic failure analysis team

B3.11 Bibliography

Wire Specifications
http://www.sae.org/standards/

Insulation Materials and Descriptions
www.thermometricscorp.com/wireabmat.html

Mishap Investigations Journal
SAE Conference July 28, 2010

B4. THE EFFECT OF VOLTAGE ON THE OXIDE LAYER OF TITANIUM by Shenia Pointer, 12th Grade, Thurgood Marshall High School

B4.1 Introduction

The goal of this project is to see what affect voltage has on the color of oxide on Titanium.

B4.1.1 Problem

What affect does voltage have on the color of oxide on Titanium?

B4.1.2 Hypothesis

If voltage affects the thickness of the oxide layer on the surface of Titanium then I should observe a change in color of that oxide layer at different voltages because as the voltage and the electrolyte collaborate, light waves interacting with the surface oxide of titanium produce beautiful and vivid colors on the surface of titanium.

Variables:
Independent Variable: Voltage
Dependent Variable: Thickness of the Oxide Layer
Controlled Variables: Type of electrolyte, the amount of Electrolyte, Coke (regular), stainless steel, and light used to examine the oxide layer

B4.2 Background

Anodizing is electrolytic passivation process used to increase the thickness of the natural oxide layer on the surface of metal parts. Anodizing increases corrosion resistance and wears resistance, and provides better adhesion for paint primers and glue than bare metal. Anodization is a deliberate oxidization of aluminum, titanium, magnesium, zinc or niobium that forms a passive barrier that protects the metal from further destruction. Pure titanium is exceedingly resistant to attack from water and air. It can develop an extremely thin skin of oxidized titanium that provides a passive barrier separating the metal from its environment.

Oxidation is the deposit that forms on the surface of a metal as it oxidizes. Oxidation is caused by an interaction of oxygen molecules with the substances they come in contact with, such as when a metal object sitting outside gets rusty. The electromagnetic spectrum is the range of all possible frequencies of electromagnetic radiation. The electromagnetic spectrum of an object is the characteristic distribution of electromagnetic radiation emitted or absorbed by that particular object. The used for modern electromagnetic spectrum extends from below frequencies used for modern radio to gamma radiation at the short-wavelength end, covering wavelengths from thousands of kilometers down to a fraction of the size of an atom.

The infrared part of the electromagnetic spectrum covers the range from roughly 300 GHz (1 mm) to 400 THz (750 nm). It can be divided into three parts:

1. **Far-Infrared**: from 300 GHz to 30 THz (10µm). The lower part of this range may also be called microwaves. This radiation is typically absorbed by so-called rotational modes in gas-phase molecules, by molecular motions in liquids, and by phonons in solids.

2. **Mid-infrared:** from 30 to 120 THz (10 to 2.5μm). Hot objects (black-body radiators) can radiate strongly in this range. It is absorbed by molecular vibrations, where the different atoms in a molecule vibrate around their equilibrium positions. This range is sometimes called the fingerprint region since the mid-infrared absorption spectrum of a compound is very specific for that compound.

3. **Near-infrared:** from 120 to 400 THz **(**2,500 to 750nm). Physical processes that are relevant for this range are similar to those for visible light. Visible light is the range in which the sun and stars similar to it emit most of their radiation. It is probably not a coincidence that the human eye is sensitive to the wavelengths that the sun emits most strongly. Visible light (and near-infrared light) is typically absorbed and emitted by electrons in molecules and atoms that move from one energy level to another. The light we see with our eyes is really a very small portion of the electromagnetic spectrum. A rainbow shows the optical (visible) part of the electromagnetic spectrum; infrared (if you could see it) would be located just beyond the red side of the rainbow with ultraviolet appearing just beyond the violent end. Electromagnetic radiation with a wavelength between 380 nm and 760 nm (790-400 terahertz) is detected by the human eye and perceived as visible light. Other wavelengths, especially near infrared (longer than 760 nm) and ultraviolent (shorter than 380 nm) are also sometimes referred to as light, especially when the visibility to humans is not relevant. The visible spectrum is the portion of the electromagnetic spectrum that is visible to human eye. Electromagnetic radiation in this range of wavelengths is called visible light or simply light. A typical human eye will respond to wavelengths from about 380 to 750 nm. A light-adapted eye generally has its maximum sensitivity at around 555 nm. The spectrum does not, however, contain all the colors that the human eyes and brain can distinguish. Unsaturated colors such as pink, or purple variations such as magenta, are absent, for example, because they can only be made by a mix of multiple wavelengths. Visible wavelengths also pass through the optical window, the region of the electromagnetic spectrum that passes largely unoccupied through the Earth's atmosphere. The visible window is so called because it overlaps the human visible response spectrum. Many species can see wavelengths that fall outside the "visible spectrum". Bees and many other insects can see light in the ultraviolent, which helps them find nectar in flowers. UV this is radiation whose wavelengths are shorter than the violent end of the visible spectrum, and longer than that of an x-ray. Being very energetic, UV can break chemical bonds, making molecules unusually reactive or ionizing then (see photoelectric effect), in general changing their mutual behavior. Sunburn, for example, is cause by the disruptive effects of UV radiation on skin cells, which is the main cause of skin cancer; if the radiation irreparably damages the complex DNA molecules in the cells (UV radiation is proven mutagen).

Table B-2. Radiation Sources and Absorption Effects

Radiation	Scale of λ	Absorption involves:
Gamma rays	pm	Nuclear Reactions
X-rays	0.1 nm	Transitions of inner atomic electrons
UV	*nm*	*Transitions of outer atomic electrons*
Visible	*nm*	*Transitions of outer atomic electrons*
Infrared	mm	Molecular vibrations
Far Infrared	mm	Molecular rotations
Radar	cm	Oscillation of mobile or
Long radio waves	>>m	free electrons

Ultraviolent light is electromagnetic radiation with a wavelength shorter than that of visible light, but longer than x-rays, in the range 10 nm to 400 nm, and energies from 3eV to 124eV. It is so named because the spectrum consists of electromagnetic waves with frequencies higher than those that humans identify as the color violet. UV light is found in sunlight and is emitted by electric arcs and specialized lights such as black lights. As an ionizing radiation it can cause chemical reactions, and causes many substances to glow or fluoresce. Most people are aware of the effects of UV through the painful condition of sunburn, but the UV spectrum has many other effects, both beneficial and damaging, on human health.

Infrared radiation is electromagnetic radiation with a wavelength between 0.7 and 300 micrometers, which equates to a frequency range between approximately 1 and 430 THz. Its wavelengths is longer (and the frequency lower) than that of visible light, but the wavelength is shorter (and the frequency higher) than that of terahertz radiation microwaves. Bright sunlight provides an irradiance of about 1 kilowatt per square meter at sea level. Of this energy, 527 watts is infrared light, 445 watts is visible light, and 32 watts is ultraviolent light.

In physics, absorption of electromagnetic radiation is the way by which the energy of a photon is taken up by matter, typically the electrons of an atom. Thus, the electromagnetic energy is transformed to other forms of energy, for example, to heat. The absorption of light during wave propagation is often called attenuation. Usually, the absorption of waves does not depend on their intensity (linear absorption), although in certain conditions (usually, in optics), the medium changes its transparency dependently on the intensity of waves going through. Reflection of light is either specular (mirror-like or diffuse (retaining the energy, but losing the image) depending on the nature of the interface. Furthermore, if the interface is between a dielectric and a conductor, the phase of the reflected wave is retained. A mirror provides the most common model for specular light reflection, and typically consists of a glass sheet with a metallic coating where the reflection actually occurs. The law of reflection states that $\theta i=\theta r$, (the angle of incidence equals the angle of reflection). Reflection of light may occur whenever light travels from a medium of a given refractive index. In the most general case, a certain fraction of the light is reflected from the interface, and the remainder is refracted. When light reflects off a material denser (with higher refractive index) than the external medium, it undergoes a 180° phase reversal. In contrast, a less dense, lower refractive index material will reflect light in

phase. This is an important principle in the field of thin-film optics. Specular reflection forms images. Reflection from a flat surface forms a mirror image, which appears to be reversed from left to right because we compare the image we see to what we would see if we were rotated into the position of the image. The electromagnetic spectrum relates to my project because it depends on what type of light you look at the sample of titanium under.

B4.3 Technical Discussion

B4.3.1 Materials

- 0-60V power supply
- Cola (regular)
- Titanium
- Stainless steel
- Graduated cylinder

B4.3.2 Procedures

1. First take (X amount of pieces) of titanium and ground brake on grid paper.
2. Then take a graduated cylinder and wrap the stainless steel around the inside of the cylinder, and pour coke (regular) in the cylinder.
3. Let it sit for 10 seconds before starting so it can settle.
4. Then attach one end of the piece of titanium to the power supply
5. Make sure the power supply start at 0 amps before placing into the solution.
6. Position the amount of voltages you want to test, for example, 20V.
7. Observe what happens to current (amps) when you but the piece of titanium in and when you take it out and observe what happens as the piece of titanium is placed in the solution and the color the oxide layer is when you take it out.
8. After you have found your observations based off the voltage you start with then make a graph of your results. (colors observed)
9. Repeat step seven if you test more than one piece of titanium at different voltages, for example, 20V and 25V.
10. Then compare and show the different data.

B4.3.3 Results

Table B-3. Color Results as a Factor of Amperage Exposure in Tests

Try	Voltage	Color
First Try	20V	Bronze
Second Try	25V	Purple
Third Try	30V	Blue
Fourth Try	35V	Light Blue
Fifth Try	40V	Lighter Blue
Sixth Try	50V	Steel Blue with a hint of Yellow
Seventh Try	55V	Pale Yellow

First the current starts at zero, then when I put the sample in the current started going up. At the 10 second rage the current decreased to ~ 1, 2 amps. At 10 seconds the amps stayed at a

low current. When I took the sample out the current went back to zero for all the voltages put on it.

My results show that the voltage has a effect on the color of oxide o titanium.

B4.4 Conclusion

My hypothesis was correct. The amount of voltage affects the thickness of the oxide layer on the surface of Titanium which then observes a change in color of that oxide layer at different voltages.

B4.5 References

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B5 The Reconstruction of Rubber Muscle Actuators for Possible MAV Development, Desmond Dixon, Grade 12

B5.1 Abstract

Compact actuation that is integrated into a structure's material system has the potential to provide rapid structural reconfiguration while reducing weight. The effect of scale (diameter and segment length) on the performance of cylindrical fiber-reinforced Mckibben like Rubber Muscle Actuators (RMA) was investigated. Activation pressure was observed for all actuators at a value that depended upon the actuation construction. If the change of diameter is done to the RMA, then this will cause the muscle contraction to alter the force because the RMA affects the physical property of the contraction in so many ways. Upon pressurization past the activation threshold, the overall force, stroke, and work capacity increased with increasing actuation length and diameter. The actuation force per unit RMA cross-sectional area was predicted, and experimentally observed, to be roughly constant after activation. By segmenting a longer actuator, a larger contraction and lower actuation force could be achieved. Though actuation forces decreased as actuator diameter and length decreased, the force per unit actuator volume was shown to increase with decreasing diameter including a roughly 4-fold increase in force/volume between the 0.5" and 0.05" actuators. However, due to the small amount of total contraction for the smaller diameter actuators, the relative work per actuation volume was decreased by roughly 35% in comparing those same actuators. Thus, small diameter RMAs have great potential to provide needed linear actuation force within adaptive material systems.

B5.2 Introduction

If the change of diameter is done to the RMA, then this will cause the muscle contraction to alter the force because the RMA affects the physical property of the contraction in so many ways. The goal of the project is to test multiple of Rubber Muscle Actuators (RMA) and compare the amount of force produced through contraction while using a pneumatic system. Some possible applications of the RMA are morphing and actual biological enhancements or attachments upon artificial objects. The artificial muscles key variables are diameter, length, and segments of the muscle that test the contraction which causes a certain amount of force. Diameter, segments, and length of the muscle are variables that change throughout testing to discover which combination creates the greatest amount of force but the amount of pressure which is the psi; never changes. The RMA's are composed of several materials like carbon fiber tubing latex, composites like 6444 Rencast and has been shrunk with shrink tubing. Each muscle is pneumatic complimented with a carbon fiber composite handle that contains a valve to insert air pressure. The actual development of the life scaled bat wing was created through a process. What actually made the bat wing significant was the properties on how the skin folds and how similar there fingers are to human beings. The selection of the bat wing was because of its simple characteristics for duplication. It was made from the strong materials such as Rencast 6444 which is an elastomer that must be cured with its opposite. It was also made from carbon fiber, which is a strong light material that becomes almost indestructible with elastomers. When the actual artificial bat wing was designed through digitations from an actual life size portrait to solid works, the build process took over. The muscles of the bat wing are remarkable because it has a foreman and fingers that actually move the bat in and out of folding position. There are three key muscles in the bat wing for during flight, the one connect to the forearm, the one connected to the fingers and the one connected to the body. The structure of the bat bones is

made from carbon fiber panel sheets and Rencast 6410 which is a durable elastomer. The Rencast 6444 used in the RMA's and the skin of the bat is a rubber elastomer which brings flexibility for necessary contraction for the rubber muscle to produce work for force and also for the bat wings ability to fold and open for flight. The actual muscle was model of the Mckibben muscle actuators which couldn't compare with the muscles made for this project, due to our amount of force. . The reason why a bat wing was use to create this project was because of the characteristics of the skin and bones during its flight motion (aerodynamics). A bat wing was used in this type project was due to the physical properties of the skin and the muscle placements among the body. The flying motion of the bat is very unique but easy to mimic with proper strength and muscle communication. What makes the bat wing different from a bird wing is its ability to fold after fully extending. When I say fold, I mean bat wing fully extends and pushes down to a 90° angle and then pulls up in one motion. On the aerodynamics part this wouldn't be possible with the addition of feathers due to the friction and stress areas. The bat wings skin actually catches the air inside its wing and creates a bubble that lets the wings glide upon. The bones of the bat wing are similar to the bones of the human, structurally and physically.

The bat wing and bird wing are two different structures and two different flight patterns; you can say that the bat has a more simple structure and flight simulation then the bird because of the surface characterization. The biggest issue with the creation of an artificial bat wing is the manufacturing difficulty of the muscles and skin. The reason it's a problem is that folding of the wing is mandatory for the aerodynamics of the flight; it is because the skin of the bat will have tremendous stress on the muscles of the wing due to its large thin surface. So the goal is to create a bat wing with the correct dimensions and proportions and also be aerodynamic in the folding process of flight. The actual wing of the bat can be related to the arm of a human being due to the similar bones such as the forearm and five fingers. The skin on the bat wing isn't the same throughout because some particular parts of the wing need more support with the intense movement with the limbs, which in the case of the bat wing the addition of fiber glass was added.

In the case of the possible morphing application, the RMA's must either be embedded into an object in which in my case a wing. How it works is if the muscle ends are attached inside and if air pressurized the inside of the muscle it will cause a bending motion outside of the wing. Other theory's are if the diameter of the muscles becomes 1/16 of an inch that is attached with other muscles in a certain position embedded in through the surface of the object.

A big factor in the experiment that plays a vital role upon success of the hypothesis is the braid angles of the carbon fiber within the rubber muscles. For example the fiber angle of 54.7°, the minimum critical length is 100% of the diameter, which essentially means that the actuator doesn't expand. On the other extreme, very large minimum critical lengths are predicted for small angles less than 5°. These may not be realistic either, as RMA thickness and stiffness may effectively limit the critical length. The objective of the project is to create adaptive, active, and multifunctional material that can contribute to the development of artificial development such as Micro Air Vehicles (MAV).

B5.3 Methods and Material

The first developed material RMA, have multiple variables: diameter, segments, thickness, and pressure. The method used to test the variables is Contraction vs. Force. What this consist of is a series of test on an Instron machine which is a machine that pulls on an object and measures the amount of lbf that is presented from the object. Besides using air in the process, the addition

of water was also instrumented to see if water pressure could produce more force than air. The first variable which is the diameter of the muscle is the one of dependent variables that plays a key role in the amount of force being produce. What makes the diameter important to the experiment is on the amount of contraction produced by the muscle. In the terms of physics, the larger diameter will make the largest contraction and produce the most force per pound. The diameter is also broken own to specific groups such as **D_{rma}** which is the outer diameter, **D_{nom}** is the diameter of the nominal or the braid of the diameter, **D_{bl}** means the bladder diameter of the muscle inside.

The next variable in the experiment is the amount of segments is forced upon the muscle. The reason why this was enforced was because the theory of a possible theory of creating joints upon the muscles. It created less force but possible bend ability that can act as an artificial pulley.

The thickness of the skin (**T_s**), wall thickness **(T_t)** and bladder thickness (**T_b**) played a key role on the amount of pressure that was resisted upon the muscle that affects the % of contraction which affected the amount of force.

The last and most important variable in the experiment that is the independent variable in the amount of force instructed upon the muscles. The force that was inserted was 40 psi which is the amount of pounds per square inch. The reason why the pressure had to be consistent throughout the experiment is because and type of increased or decreased pressure can alter the amount of contraction produced and there for disrupting the correct amount of force truly produced. The test machine used to determine the amount of contraction and forced produced from each muscle was the Universal Testing Machine. It functions by introducing a test to the machine that specifically instructs it to apply force upon the subject and calculates the amount contraction and force produced by the RMA while inflated with air or water at a specific pressure. The data collected from the experiment is then inputted into excel and cleaned for data use. When the data of test was finished cleaning out it had over 10,000 pieces of data due to the way that the Universal Testing Machine collects every description every second of the experiment for up to 10 minutes.

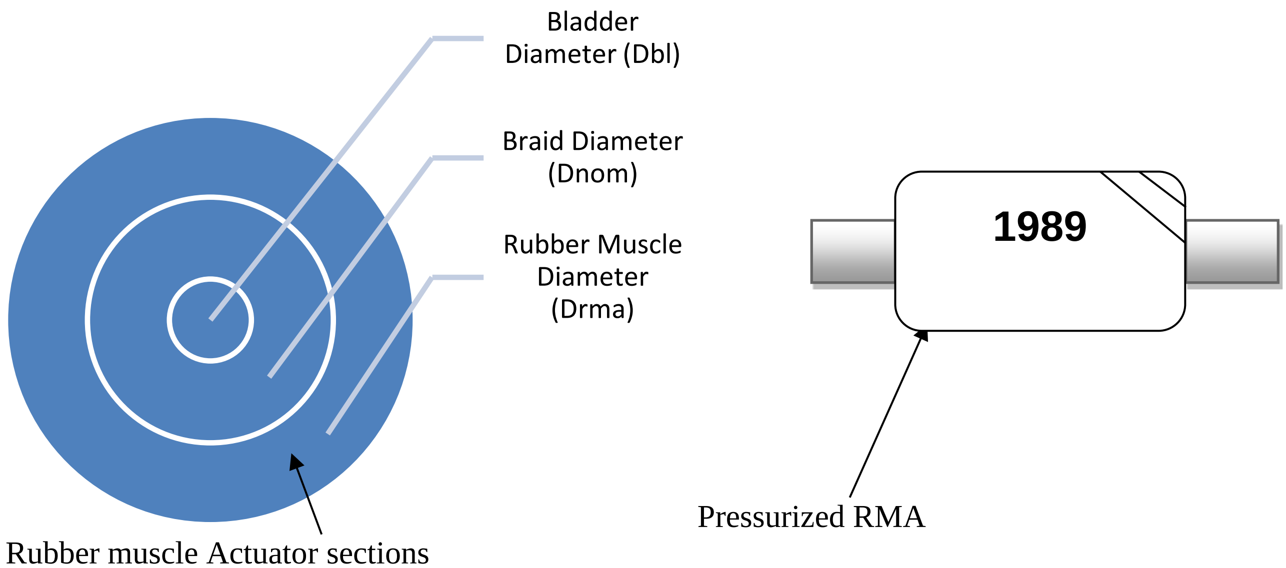

Figure B-10 RMA Material

Table B-4. Specimen Characteristics

Specimen	Drma (in)	Dnom (in)	Ts (in)	Ts/Dnom	Dbl (in)	Tb (in)	Tb/Dbl	Tt (in)	Tt/Drma
BD500L5-1	0.648 in	0.50 in	0.074 in	0.148 in	0.375 in	0.063 in	0.167 in	0.137 in	0.211 in
BD500L5-4	0.69 in	0.50 in	0.095 in	0.148 in	0.375 in	0.063 in	0.167 in	0.158 in	0.228 in
BD500L5-5	0.60 in	0.50 in	0.050 in	0.190 in	0.375 in	0.063 in	0.167 in	0.113 in	0.118 in
BD500L5-6	0.639 in	0.50 in	0.070 in	0.100 in	0.375 in	0.063 in	0.167 in	0.132 in	0.207 in
BD500L10-7	0.595 in	0.50 in	0.048 in	0.139 in	0.375 in	0.063 in	0.167 in	0.110 in	0.185 in
Average	**0.634** in	**0.50** in	**0.067** in	**0.134** in	**0.375** in	**0.063** in	**0.167** in	**0.130** in	**0.204** in
BD250L2.5-1	0.341 in	0.25 in	0.046 in	0.182 in	0.188 in	0.032 in	0.168 in	0.077 in	0.226 in
BD250L2.5-2	0.322 in	0.25 in	0.036 in	0.144 in	0.188 in	0.032 in	0.168 in	0.068 in	0.210 in
BD250L2.5-3	0.345 in	0.25 in	0.048 in	0.190 in	0.188 in	0.032 in	0.168 in	0.079 in	0.229 in
BD250L5-4	0.371 in	0.25 in	0.061 in	0.242 in	0.188 in	0.032 in	0.168 in	0.092 in	0.248 in
Average	**0.345** in	**0.25** in	**0.047** in	**0.190** in	**0.188** in	**0.032** in	**0.168** in	**0.079** in	**0.228** in
BD125L2-1	0.157 in	0.125 in	0.016 in	0.128 in	0.125 in	0.031 in	0.248 in	0.047 in	0.299 in
BD125L2-2	0.156 in	0.125 in	0.016 in	0.124 in	0.125 in	0.031 in	0.248 in	0.047 in	0.298 in
BD125L2-3	0.147 in	0.125 in	0.011 in	0.088 in	0.125 in	0.031 in	0.248 in	0.042 in	0.286 in
BD125L5-7	0.18 in	0.125 in	0.028 in	0.220 in	0.125 in	0.031 in	0.248 in	0.059 in	0.325 in
BD125L10-4	0.157 in	0.125 in	0.016 in	0.128 in	0.125 in	0.031 in	0.248 in	0.047 in	0.299 in
Average	**0.159** in	**0.125** in	**0.017** in	**0.138** in	**0.125** in	**0.031** in	**0.248** in	**0.048** in	**0.302** in
BD050L5-4	0.112 in	0.55 in	0.029 in	0.518 in	0.055 in	0.010 in	0.182 in	0.039 in	0.344 in
BD050L2-3	0.116 in	0.55 in	0.031 in	0.555 in	0.055 in	0.010 in	0.182 in	0.041 in	0.349 in
BD050L2-1	0.119 in	0.55 in	0.032 in	0.582 in	0.055 in	0.010 in	0.182 in	0.042 in	0.353 in
Average	**0.116** in	**0.55** in	**0.030** in	**0.552** in	**0.055** in	**0.010** in	**0.182** in	**0.040** in	**0.349** in

*Overview of variables

***Drma**-Diameter of the Rubber Muscle Actuator; ***Dnom**- Braid Diameter; ***Ts**-Skin thickness; ***Dbl**-Bladder diameter; ***Tb**-Bladder thickness; ***Tt**- wall thickness; **BD**- Braid diameter: **L**-Braid length

B5.4 Results

RMA L-is the length of the actuator; Segm. L- is the segments length; %L is the contraction rate.

Table B-5. RMA Results by Specimen

Specimen	RMA L(in)	Segments	Segm. L(in)	Force(lb)	%L @40psi	Vol@40psi	charL(in)	segmL/charL
BD500L5-1	5.0 in	1	5.0 in	157 lbf	26%	25.9 lb/in²	2.35 in	2.13 in
BD500L5-4	5.0 in	1	5.0 in	145 lbf	26%	24.2 lb/in²	2.35 in	2.13 in
BD500L5-5	5.0 in	1	5.0 in	139 lbf	26%	23.1 lb/in²	2.35 in	2.13 in
BD500L5-6	5.0 in	1	5.0 in	105 lbf	26%	17.5 lb/in²	2.35 in	2.13 in
BD500L10-7	9.8 in	1	9.8 in	179 lbf	20%	22.7 lb/in²	2.35 in	4.26 in
BD500L10-7	9.8 in	2	4.9 in	165 lbf	23%	24.1 lb/in²	2.35 in	2.09 in
BD500L10-7	9.8 in	3	3.25 in	142 lbf	24%	22.1 lb/in²	2.35 in	1.38 in
BD250L2.5-1	2.5 in	1	2.5 in	38.9 lbf	24%	23.8 lb/in²	1.18 in	2.13 in
BD250L2.5-2	2.5 in	1	2.5 in	35.4 lbf	24%	21.6 lb/in²	1.18 in	2.13 in
BD250L2.5-3	2.5 in	1	2.5 in	40.3 lbf	24%	24.6 lb/in²	1.18 in	2.13 in
BD250L2.5-3	2.5 in	2	1.13 in	28.7 lbf	40%	28.9 lb/in²	1.18 in	0.96 in
BD250L5-4	5.1 in	1	5.08 in	51.3 lbf	19%	25.5 lb/in²	1.18 in	4.32 in
BD250L5-4	5.1 in	2	2.5 in	47.1 lbf	19%	23.4 lb/in²	1.18 in	2.13 in
BD250L5-4	5.1 in	3	1.60 in	39.9 lbf	19%	19.8 lb/in²	1.18 in	1.36 in
BD250L5-4	1.5 in	3	1.60 in	33.3 lbf	62%	52.5 lb/in²	1.18 in	1.36 in
BD125L2-1	1.88 in	1	1.88 in	4.2 lbf	14%	5.9 lb/in²	0.59 in	3.20 in
BD125L2-2	1.94 in	1	1.94 in	2.3 lbf	13%	3.1 lb/in²	0.59 in	3.30 in
BD125L2-3	1.75 in	1	1.75 in	6.2 lbf	15%	9.3 lb/in²	0.59 in	2.98 in
BD125L2-3	1.75 in	2	0.81 in	4.1 lbf	15%	6.2 lb/in²	0.59 in	1.38 in
BD125L5-7	4.96 in	1	4.96 in	6. l7 lbf	11%	7.7 lb/in²	0.59 in	8.44 in
BD125L5-7	4.96 in	2	2.4 in	6.1 lbf	11%	7.0 lb/in²	0.59 in	4.09 in
BD125L10-4	9.88 in	1	9.88 in	12.1 lbf	15%	18.1 lb/in²	0.59 in	16.8 in
BD125L10-4	9.88 in	2	4.86 in	9.4 lbf	15%	14.1 lb/in²	0.59 in	8.27 in
BD125L10-4	9.88 in	4	2.34 in	9.0 lbf	15%	13.5 lb/in²	0.59 in	3.98 in
BD050L5-4	4.8 in	1	4.8 in	3.4 lbf	4%	9.0 lb/in²	0.24 in	20.4 in
BD050L2-3	2.17 in	1	2.17 in	2.7 lbf	9%	15.9 lb/in²	0.24 in	8.42 in

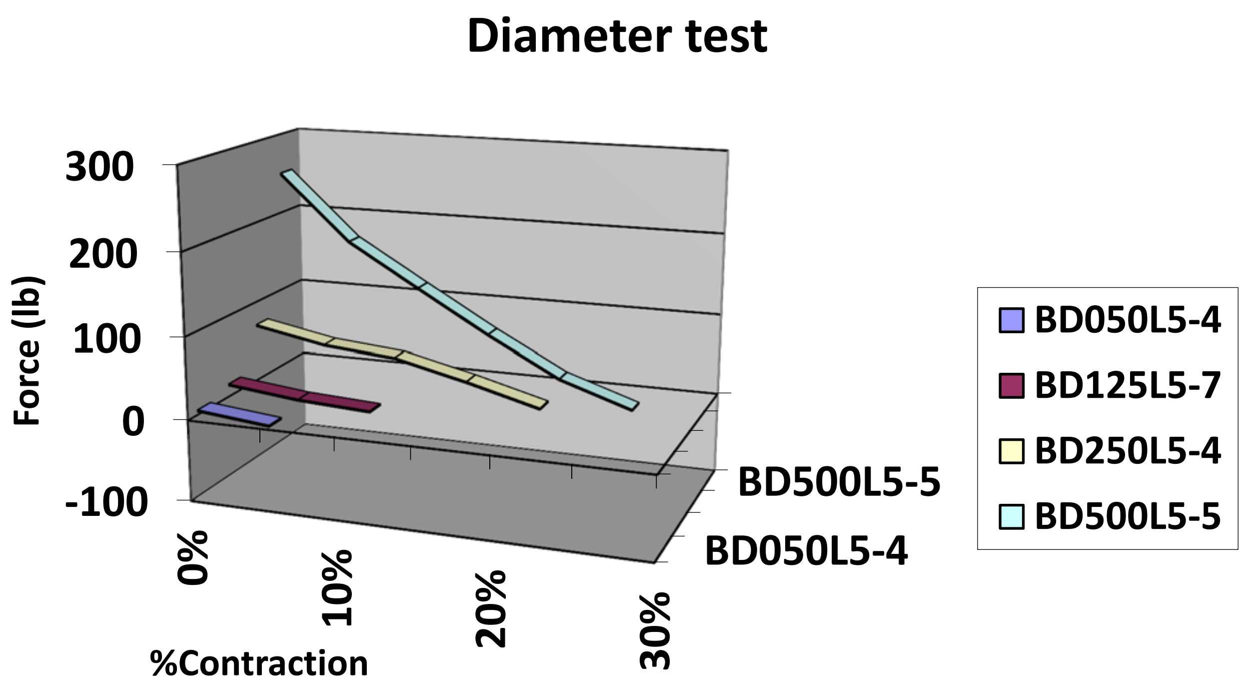

Figure B-11 Diameter Test

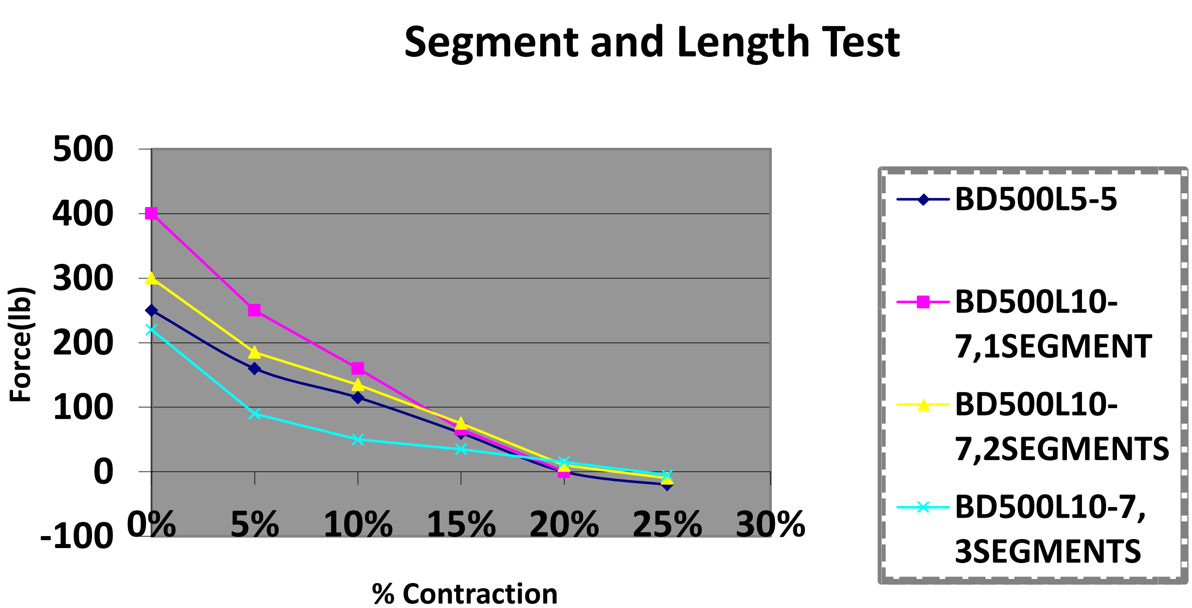

Figure B-12 Strength and Length Test

B5.5 Discussion

A series of cylindrical elastomer composite Rubber Actuators were fabricated with four different diameters and at least two lengths each, and were tested to investigate the effect of diameter, length, and segmented length on performance. Experimental actuation forces compared well to a simple model previously developed. Experimental activation pressure increase somewhat as diameter decreases and are predicted to be a direct function of the ratio of diameter per RMA skin thickness stays constant, however, maintain a constant ratio which in practice is more difficult. For an RMA of a given length and diameter operating at a fixed pressure, increasing the number of segments decreases the actuator force but increases the contraction. An RMA with a length of *nX* and *n* being the segment will produce a higher force for the same pressure than a single segment RMA of length X for the same diameter. In other words, it is better to have one longer segmented actuator, than many short actuators in series, when the segments are the same length as the short actuators if one wants to obtain highest force.

Though actuation forces decreased as actuator diameter and length decreased, the force per unit actuator volume was shown to increase with decreasing diameter including roughly 4-fold increases in force/volume between the 0.5- and 0.05-inch actuators. However, due to the small amount of total contraction for the small diameter actuators, the relative work per actuation volume was decreased by roughly 35% in comparing those same actuators. Thus, small diameter RMAs has great potential to provide needed multifunctional capabilities for Micro air Vehicle (MAV). Future work includes investigating the sheet-type rubber muscle actuators, and testing the current actuators with non-compressive fluid.

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B5.7 Acknowledgements

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APPENDIX C
Overview of Academic Year 2011-2012
Thurgood Marshall High School Math and Science Club Meetings

The Thurgood Marshall Math and Science Club meets every Wednesday at 4:00-5:30 PM in Room 1113 or in the cafeteria. The format for every meeting is similar. Prior to Wednesday's Math and Science Club meetings the officers and captains hold a planning meeting.

C1. Weekly Planning Meetings

Planning meetings are held on Mondays and they are held to delegate responsibilities and give reports on the upcoming and past events of the club. The club officers and focus team captains were required to attend and manage these meetings. The main purpose of these meetings was to make an agenda for the next club meeting, receive updates from each focus team, and air any "dirty laundry" we may have. During these meetings this year, we discussed things like events held at our school sponsored by us, for example, the installation of club officers, the awards ceremony, 8^{th} Grade visitors, visits to feeder schools, and the visit from Dr. Stevens from the AFRL/RX.

C2. Weekly Club Meetings

The focus of the meetings is based on the activities of the time period. From September through December, most meetings are about the Science Fair with work sessions to help students complete a successful project and periodically presenting their progress and projects to the other members. If we have any new, conditional members, we have introductions and a few activities that allow us to meet and greet. After science fair, which is around December, we try to focus our club meetings on our focus teams and the activities they have coming up. From the start of the school year until March, our club pays much attention to T-Mal, sponsored by the National Society of Black Engineers Jr. Chapter.

Between the months of January and March, our club focuses on Robotics and Chess activities. For the rest of the school year, as it gets warmer outside, our club focuses on Flight and Environmental team activities.

Our club meeting usually work like this: the president begins each meeting with a call to order and informs all members of the agenda. The secretary of science does role call and then the secretary of math reads the minutes from the previous meeting for approval. Next, the president continues on with new business and announcements and has team captains come forth with any reports. Students usually start off with a math and science problem to get them thinking. Then, we move on to the focus of the meeting which can be a keynote speaker, debrief from the president, Engineering of the Month activity, or a fun science lab.

Key speakers provide information of math and science and real life applications. In the 2011-2012 school year, we have had several speakers ranging in various STEM fields. Below are a few of the guest speakers we acquired throughout the school year:

In October of 2011, Dr. Robert Williams visited the club to introduce the Tech^Edge Discovery Lab. He discussed the purpose and benefits of being a member of this team and offered club members the opportunity to earn their way into the summer program by starting beginner's virtual reality courses during the school year. Also, during this month, 2^{nd} Lt. Tundra visited the club and spoke about the Aerospace Propulsions Outreach program. Lt. Rebekah Mazany too came during the month of October and spoke on the Scramjet and the Mach number. They also brought out a jet engine in the parking lot to demonstrate their topic. Lastly, Dr. Grote

from the Materials and Manufacturing Directorate AFRL, spoke on light and lasers and how we can make them visible in the air as well as how it is used in the lab to prepare for combat. To give the students more hands on interaction he brought along a few demos. The demos focused on a few concepts like the difference between visible light and light we can't see to demonstrate this idea he used a remote control and a cell phone. The purpose of this demo is to be able to see invisble light from a remote control through the camera of a cell phone. Another demo he did involved using an I Pod and the frequency of light to play the music from the device out of the speakers. He also showed the members how far different light can go in some of his other demos.

In November of this school year, Mr. Shane Howard, a regular to our club, spoke about fluid power and pneumatics. Mr. Shane is one of our very frequent, very helpful robotics mentors. It was then that he invited us to visit the company that supplies our team’s pneumatic materials. In preparation for the science fair season, Central State University faculty with all different backgrounds in STEM visited our club and gave a well-needed presentation on what to expect for this science fair season and what we needed to do if we wanted to succeed at Regional Science Fair and/or advance to State Science Fair. Also in November, Mr. Carl Moyer, a member of the NAACP, came to our club meeting to ask us to take interest in the ACT-SO (Afro Academic Technological scientific Olympics) program, sponsored by the NAACP. This was a competition that we could enter with basically any kind of presentation ranging from film, science, contemporary music, visual arts, etc. Of course, his purpose was to persuade us to enter the sciences category. Lastly, in November, a few students from the National Society of Black Engineers at Wright State University visited our meeting to persuaded us to continue down the current path that we were on, finding a career in math and science.

Emory Beck is a former Thurgood Marshall student who visited the club in December of 2011. He was the president of the math and science club for the 2009-2010 year. Emory came back to the club to talk to the members about transferring from high school to college. He explains how more intense college is and how it should be taken serious when you first start. Emory is majoring in mechanical engineering at University of Cincinnati where he is also involved with the Co-op program. University of Cincinnati is well known for its Co-op students and collaborates with big business around the country.

On February 10, 2012 a group of young women from Spelman College in the computer science program came to visit. This trip is part of Spelman's month long activities and campaign to promote STEM among women and minorities. The Spelbots, Spelman college, are a team of African American female students who conduct robotics research and compete nationally in robotics and computer science competitions. These young women also conduct K-12 educational outreach all across the nation. During their visit they demonstrated their robot that could possibly fight against childhood obesity. In addition the spelbots and Thurgood Marshall's robotics team appeared on television as women in engineering. Although, our team is not all women for the most part young women have contributed major components to the robot.

Also in February 2nd Lt Patrick Lin from the Aero medical test lab at Wright Patterson Air Force Base came to visit the club. The Aero medical test lab activity provides premier safe-to-fly test and evaluation services, expertise and facilities for DOD Aero medical equipment. The Aero medical test lab provides service to the Air Mobility Command, Air Combat Command, Air Force Special Operations Command, International Community and commercial industry. Lt Lin's job is test manager of the Aero medical supplies he makes sure that equipment produced by

them is safe enough to be used for military use. In addition to telling us what he does on the job Lt Lin provided a hands on lab testing the ultrasound in different parts of the body.

In March Mr. Eric Joyce a robotics team mentor came to visit the club to talk about simple machines and how they are used in everyday life. Mr. Eric's gave this presentation to get the robotics team aware of some of the things that are used on their robot. He went through all the simple machines and they include: pulleys, levers, wedges, wheel and axle, inclined plane and screws. After he explained the simple machines we then gave examples of simple machines that were exhibited on the robot and watched some battlebots and the simple machines they used to battle with.

On May 16, 2012, Thurgood Marshall Math & Science Club and Air Force Research Lab personnel, led by Dr. Katherine Stevens and club officers joined together to experience three educating, interesting hands-on labs most of which involved Nano particles and cells. After a brief PowerPoint on AFRL Materials and Manufacturing, we split into three groups to start the fun labs. At station 1 we were able to observe how the Nano particles change with various chemical reactions with three mini labs including seeing how they work in, the dark. Another short demonstration involved observing how objects interact with environments on their surface so we burned wool and a nail to observe this investigation. We observed that burned particles from the wool just falls off while the nail just gets black but you could wipe it off later. Lab 3 gave us an outlook on solar cells and how we could bend steel. We measured the energy in various objects and even ourselves to see which one was the better conductor. After all the fun labs we gathered for a successful robotics demonstration. After the club officers presented Dr. Stevens, her personnel and another special guest with club t-shirts, mentor cougar, and notebook with a pen.

On May 23rd the club had 3 special visitors: Jhaelynn Elam, 2010-2011 Math and Science club president; Omar Gutierrez 2007-2008 robotics captain; and some sensors guests from Wright Patterson Air Force Base. During this visit they talked to us about becoming a part of a STEM Major as well as the transition from high school to college.

C3. Focus Team Activities

C3.1 Chess Team

During our year of chess we have participated in the engagement of the entire Math and Science club, under the leadership of its captain, Brittany Davis-Rowe. These events include: Math and Science Chess Day, Presentations on Chess (The basics for beginners) as well as the Chess tournament held on 3 May 2012. We have had some bumps along the way with chess and its’ strive to move along smoothly.

With the help of the few but engaged individuals as well as mentors and advisors, we were able to say that we had an effectively engaged year that consisted in challenging opponents as well as building ourselves up as a individuals that come together as a whole to represent Thurgood Marshall High Schools’ Math & Science Club’s Chess Team. The Math & Science club Chess day was a day fully dedicated to the Chess team. The Math & Science club participants were divided by knowledge of the game of chess as well as grade to effectively have a peer to peer mentor establishment in learning strategies of chess. Each team learned a strategy on how to play chess efficiently whether it involved defense, offense, capturing early in the game or moving the pieces in the start of a strong game. The meeting went well but much could have been done more to this. The power points were there to be a visual aide for those individuals who

may have needed to refresh or get a full concept of what chess involved as well as to the basics of moving individual pieces in essence to putting the pieces into the proper place.

The Chess tournament was held 3 May 2012. There were 8 individuals that physically participated in the Chess tournament for the “Win” of being this year’s Chess Champion. Each one of these individuals had their own unique style of executing the game. In the end there could only be one “winner” as they were all winners for stepping up to participate in such a thinking and strategic game that takes time and well thought out moves. The First Place winner was a freshmen and the Second Place winner was a senior.

C3.2 Flight Team

The flight team has done a few exciting activities throughout the 2011-2012 school year. In August the flight team was honor to host a booth at the Jet World Masters hosted by Wright Patterson Air Force Base. At the booth we had daily paper airplane contest where children in different age groups competed with their design. We also had flight simulators where children could fly planes like those on the runway strip. This was the highlight of the flight team's year because the Jet World Masters is held every 30 years with teams from all over the world to compete for the title as the Jet World Master.

The flight team has also done some work with remote control airplanes and simulators at the feeder schools and 8th grade parent’s nights to introduce the younger generation to aviation. Throughout the 2011-2012 school year, the flight team did the following; fix the model airplanes and flew them inside, as well as helicopters, this served as a daily meeting activity on Thursdays after school.

This year the club participated in Aviation Awareness month where they were involved in hands on activities. Some of the activities that took place during aviation awareness month in April included the string rocket races, rockets made of milk cartons and balloons and paper airplane designs with straws that were supposed to shoot in the air. Finally we had a speaker Mr. Hank Boust, he came out on May 2nd and talked about drag, lift, thrust, and gravity in relevance to propulsion with the wind tunnel. There were several mini-demos including: making a model for wind tunnel, egg carton gliders, and ring wing gliders.

C3.3 Robotics Team

The robotics build season began January 6, 2012 with announcements of what is expected from participating members and what the year would look like. Members were expected to give up 6 weeks of their time and about 4 hours a night to build the robot. On Saturday January 8, 2012 the robotics team had their first official kick-off in Cincinnati at Colerain High School with 16 members and 7 mentors in attendance there it was announced that this year's game is Rebound Rumble. The robotics team would meet every day Monday – Friday from 4:00 P.M. – 7:00 P.M, sometimes later, and weekends if there were things that needed to be done immediately.

The team was split up into 4 groups wiring, programming, mechanics and pneumatics. Usually all four groups would come back together at the end of a meeting day to discuss what they accomplished and what would be next. The team received help from mentors that came out from Booz-Allen-Hamilton, Wright-Patterson Air Force Base, and Brainerd Industries. Throughout the build season, the robotics team captain, Takeisha Hankins, would keep the general body of the club updated on the progress of the robot. The robotics debrief was held

May 1, 2012 to discuss some of the things we learned , what we could do better to make a more productive year and to follow the schedule throughout the year.

C3.4 Academic Quiz Team

For the 2011-2012 school year, the Math and Science Club followed up with what was established last year and allowed its students to take part in a Try-Math-a-Lon, also known as T-mal. This program is designed to increase the students' Math SAT and ACT scores by bringing in mentors with STEM backgrounds not only from the Air Force Research Lab, but also form the surrounding universities like Wright State and University of Dayton.

T-mal is also a fun competition! Every other Saturday morning of the month between September-March, the students would gather at Thurgood Marshall High School; ready to be enriched for our standardized tests as well as one of our upcoming competitions. Not only did our club members take home 1st and 2nd place at the local competition, but we also received the chance to compete in the world competition in Pittsburg, Pennsylvania. The T-mal program has also done alot for our students' test scores; proving that the program has raised students' Math ACT scores by an average of three points.

C3.5 Tec^ Edge Team

In Tec ^ Edge there was a group of five girls from the club who meet every Tuesday for about 6 weeks to work in the virtual world with a mentor from the Tec^ Edge team on base. The team was a part of VRA (Virtual Reality Academy) where they worked with computer scripting and widgets to communicate in the virtual world so they could be used for disaster preparedness for the state of Ohio. The team learned that second life is a more public virtual world than Imprudence where they had their meetings regularly. Because Imprudence is an older viewer it wouldn't allow them to use media prims. Media prims are used in the virtual world so that you are able to use the internet using coding and scripting for uses like widgets.

Their project is to create an easier way for people to find out the weather, police reports, traffic and news for the selected cities we chose. During their time in the virtual world they learned how to build, save, rotate and share things. This was a very difficult task at first because things are not the same in the Virtual world as they are in the real world. Things tended to become attached to your avatar or sometimes aren't completely aligned. While working on their project they learned how to add textures to the boxes we created using the PowerPoint application. This was probably the easiest part of the project because later it became more complex with a few computer scripts. Using these scripts we were able to enable the buttons to work with our selected city.

Once you have chosen a city, you have now enabled the top buttons to work for that specific city that you have chosen. The reason it lags in communication with the server sometimes, is because it is more specific than broad and sends you to a specific website rather than various websites. The script plays an important role, because it tells the button what to do and what to show. We understand why call numbers are important, because it allows the different widgets to communicate with each other. In scripting, one important rule to remember is if you make one mistake, you make an overall mistake that will cause the script to not properly function. And in that case in the real world, this will not make the consumer happy which will cause your product to be a loss. Another reason as to why the script needs to be perfect is because; a change in the URL can send you to a different website that may not be what you were

aiming for. The reason all of the boxes communicate with each other is through the command center.

After the students finished this project they moved on to a different class. Two of the members moved on to the Smartphone academy where they learned about Smartphone applications. Three of the members moved on to the computer vision academy where they learned about the vision of a computer and how it sees through the Kinect sensor.

C4. Feeder School Activities

Throughout this past school year, the Math and Science Club has been more involved with the students at Westwood PreK-8 than we have any other year. We even went as far as to helping the students construct their own Westwood Math and Science Club, where they elected their own leadership and delegated roles amongst themselves. Besides the regular visitations to Westwood to assist them in running their own Jr. Math & Science Club, we've had three major events at Westwood. The first major event was when the club members showcased the various branches of the club (Robotics, Environmental, Chess, AQT, Trebuchet, and Flight) through a fun activity called "The Mall of Math and Science". The activities included: creating and eating an edible compost, playing an AQT game, flying remote control planes, driving the Robotics team's robot, playing Kinect on the Xbox 360, flying 3D models of airplanes on flight simulators, and playing chess.

The second major event was when we came to Westwood to review and judge the students' science fair projects. We judged them on a standard, unbiased basis, and explained to each student what they needed to fix on their project to attain a better grade for next time. It definitely was a learning experience not only for the Westwood students, but for the TMHS Math and Science Club judges as well; we learned the intricacies that are involved in the judging of projects. At the conclusion of the judging, we came back to host an award ceremony for students who earned ratings of "Good" or better. The students received a certificate, a bag, and a portfolio for a job well done.

The third event was on April 12th where we held environmental activities for the Westwood students to celebrate Earth Day. These activities included: organic gardening, hard vs. soft water properties, and an even teaching the properties of distilled water and its uses.Next year, and for the years following, the TMHS Math and Science Club hopes to be even more involved with not just Westwood, but with other middle and elementary schools as well. We believe it's important to foster an interest for math and science unto children as young as possible, so they may grow into the scientists, mathematicians, and engineers that our society will need in the future.

C5. Club Field Trips

Throughout the school year the Math and Science Club went on field trips to places relevant to advancing student interest in the club and STEM applications. These trips included:

C5.1 Clippard Trip

On November 3, 2011 the robotics team was invited by Mr. Shane Howard to take a tour of the Clippard manufacturing facility. Mr. Howard is one of the mentors for the robotics team and wanted the team to be familiar with some of the equipment they use on their robot such as Pneumatic air cylinders and air compressors. During the tour at Clippard the team learned how air cylinders are made in mass production and how products are made at the factory and later

sent to other companies. The team also noticed the work force in the facility there seemed to be more women working which kind of shocked the students.

C5.2 UD with DECA University of Dayton Trip

On November 4th the Math and Science club took a trip to DECA (Dayton Early College Academy) and The University of Dayton (UD). We were given a tour of some of the areas where research and tests were done with lasers. We were told the importance of accuracy of lasers and coding that involved pulses as well as the way lasers interact with different colors and sound waves. There we learned how lasers omit off certain colors. As a plus, we were shown a demonstration on music and its effects of vibrations, in which a laser can follow certain points to make different patterns and designs based on sound waves and pulses of the music. After, we were guided to the University of Dayton and their physics department.

We were divided into two groups and taken through different areas where physics is done and how they incorporated their studies for the world today. We learned about light-bulbs and their efficiency depending on materials. We learned about micro fibers and the way that they are looked at under a microscope after being stretched into tiny fibers. We also looked at how one beam of a laser at a certain rate can give off bigger, much powerful light that can be blinding to the retina of the human eye and cause blindness. (This was a way of showing safety precautions in the lab—wearing goggles and appropriate attire is necessary). We were finally dismissed had pizza and handed out favors from the Math and Science club to the DECA group and departed back for school.

C5.3 FIRST Robotics Buckeye Competition

This year's 2011-2012 Robotics team had the opportunity to compete in the Buckeye Regional Competition held in Cleveland, OH at The Cleveland State Wolstein Center. The game for this year is Rebound Rumble. The goal in this game is to create a robot that can play a game of basketball making anywhere from 1,2 or 3 points during the tele-operated period and anywhere from 2,4 or 6 points during the autonomous period. This game also had another catch the team had to get their robot to balance resulting in 10 points if executed successfully. Before the team competed at Buckeye Regional the team made a trip to Knoxville, TN to watch a few matches just to get an idea of how the game is played.

In effort to get this far the team spent on average 6 days a week and a total of 300 hours working on their robot. This year there were a few new concepts as well as some recycled that the team used to put together an overall idea. The goal was to make a machine that used basic mechanical ideas like conveyer systems and wheels to feed the ball into the hoop. The builders came up with a mechanical arm powered by an air compressor to pull the balance down during the game. The programmers used C++ programming for the robot as well as a camera to guide the robot on the field to find any balls that were in sight. As a result the robotics team packaged a fully functional robot on February 21, 2012. On March 23rd and 24th the team competed in qualification matches at the Buckeye Regional competition placing 42nd out of 60 teams.

C5.4 Knoxville Robotics Trip

On March 3, 2012 Thurgood Marshall's Robotics team made a visit to the Museum of Science and Energy located in Oak Ridge, TN. The museum is a dedication to the WWII Manhattan project and some of the science that emerged in Oak Ridge. While exploring the museum the students learned a lot about some of the events in WWII and how scientists in Oak

Ridge played a big roll in producing Y-12 for the infamous bombs "Little Boy" and "Fat Man" dropped in Japan. The "Earth's Energy Resources" exhibit is an exhibit that's filled with optical illusions, robotic arms and a plasma ball that explores the world of science in everyday life. The "Atoms and Atom-Smashers" show uses a Van De Graaff generator to show how atoms in the human body move.

C5.5 Motoman Robotics Trip

Founded in 1989, the Motoman Robotics Division of Yaskawa America, Inc. is a leading robotics company in the Americas. With over 230,000 Motoman robots installed globally, Yaskawa provides automation products and solutions for virtually every industry and robotic application; including arc welding, assembly, coating, dispensing, material handling, material cutting, material removal, packaging, palletizing and spot welding.

National Robotics Week was instituted by Congress as the second full week of April every year. 2012 marks the third year for National Robotics week and its stated purpose is to recognize robotics as a key technology for our nation’s economy and, more importantly, to foster interest in the STEM (Science, Technology, Engineering and Mathematics) disciplines among students. In the spirit of National Robotics Week, Motoman Robotics, a division of Yaskawa America, Inc., hosted Thurgood Marshall High School Robotics team 2665, provided facility tours, and spoke to them on the roles they could play in the future of their business. In addition, representatives from several local automation companies and universities were invited to support Motoman Robotics’ efforts and commitment to robotics in the Miami Valley. Companies and universities represented include: OTC Daihen, PDSI, Rixan Associates, Edison Community College, Fortis College, Sinclair Community College, University of Dayton and University of Dayton Research Institute.

C5.6 NSBE National Conference

This year, the Math and Science Club members took on a dual-role to be NSBE Jr. Chapter members. Sixteen students took part on a 3-day trip to the National Conference with a few NSBE mentors. The conference was held at the David H. Lawrence Convention Center in Pittsburgh, Pennsylvania. On the first day, we were split into groups and taken on separate tours, one of the University of Pittsburgh, and the other of Carnegie Science Center. We later returned to the Convention Center where we participated in workshops, the first RC Aircraft and the other of the engineering behind a disk jockey (DJ). Finally to end the day, we listened to a guest speaker and a memorial of one of the NSBE chairmen. The next day we participated in workshops and job and college fairs. Most of the students that participated in the RC Aircraft workshop painted their rockets in preparation for flight. At the end of that day, we attended a junior chapter social, which was a talent showcase. On our final day in Pittsburgh, we flew the rocket we had been working on. Then we returned to the Convention Center for an awards luncheon. After the luncheon we left Pittsburgh to return to the school.

C6. Science Fair Cycle and Awards

Every year, any student who wishes to be in our club must participate in the school science fair. At the school science fair, we had a great number of participants. And the Dayton District Science Fair, we had the largest number of students from any high school there and also conquered awards from every category. For the West District Science Fair, our club took about 10 students and the awards that our school took home are listed below:

C7. Research Projects

Below you will find all of the research projects that placed and won awards at the regional level. This year, we also had two projects receive Superior ratings and moved on to the State Science Fair competition. This was Takeisha Hankins, Grade 12, and Anthony Williams, Grade 11.

- 2 Superior Projects qualify for State Science Day and 12 Special Awards
  - Infoscitex $2000 Scholarship Cash Awards (1 time award and good at any college/ university) – Eliza Straughter and Brittany Davis-Rowe: Grade 12
  - CSU Manufacturing Engineering Department – Boeing Scholarships of $3000 per year (renewable 3 more years for total of $12,000) Brittany Davis-Rowe, Tiarra Hayes, Eliza Straughter and Takeisha Hankins: Grade 12
  - Dayton Advocates for Computing Young Women Award ($50 Cash): Eliza Straughter: Grade 12
  - Institute of Electrical and Electronic Engineers Achievement Award ($125) Second Place – Eliza Straughter: Grade 12
  - Institute of Environmental Sciences and Technology ($100): Takeisha Hankins: Grade 12
  - Materials and Manufacturing Award ($250): Takeisha Hankins: Grade 12
  - MacAulay-Brown for "Excellence in an Engineering Science Project" ($250) – Brittany Davis-Rowe: Grade 12
  - United States Air Force Certificate of Achievement Award – Eliza Straughter: Grade 12
  - Department of Water Resources Grant – Jasmin Sanford: Grade 10
- State Science Fair special awards
  - Milt Austin Aquatic cash award ($50): Takeisha Hankins: Grade 12

C7.1 Publication in the Ohio Journal of Science

Takeisha Hankins Vice president of the Math and Science club was recently published in the Ohio Journal of Science this past April. In the April 2012 issue she was published as a first author for her superior project exhibited at the Ohio State Science Day May 7, 2011. Because of her publication Takeisha went to the 121st Annual meeting hosted by The Ohio Academy Science at Ashland University on April 14, 2012. There she presented her project to another set of judges where she could possibly be chosen as an observer at the American Journal of Science held in Boston. During the meeting Takeisha met with different Undergraduate students being published as well from places all over including Brazil. Takeisha describes her experience as rewarding becoming one of the first students in her school to be published as a first author in an international journal.

C8. Installation and Awards

This year the Math and Science Club hosted its second annual Installation and Awards banquet on May 9, 2012. The purpose was to install the new officers for the 2012 - 2013 school year and to say goodbye to our outgoing 2011 - 2012 officers. The following outgoing officers were as follows: Eliza Straughter President, Takeisha Hankins Vice President of Science, Chris Ray Vice President of Math, Jasmin Sanford Secretary of Science, and Kadijah Taylor Secretary of Math. Our incoming officers are as follows: Jasmin Sanford Vice President of Science, Kadijah Taylor Vice President of Math, Zakkiyat Muhammad Vice President of Outreach, Shepria Pointer Secretary of Math, Khalyn Miller Secretary of Science and Kyle Knight

Secretary of Outreach. Because it states in the charter that only a rising senior that has served an official term, there will be no president for the 2012-2013 school year. After installing our new officers we had a break and then had a guest speaker: Mr. Jeremy Warren who is, like Mr. Shane a robotics mentor. After our speaker we had our awards, recognizing the team participation throughout the school year.

C9 Club Charter Modifications

The Math and Science Club made some changes to their charter in order to make the club run more smoothly. The charter is similar to the constitution in that it is a living document, changes were made on subjects that were not specified or mention that sometimes made running the club harder.

The following changes to the Math and Science Club Charter

- Changing the year from 2011-2012 to 2012-2013
- Vice President of Outreach will work with the vice presidents of math and science in all duties and preside over meetings in the absence of the vice presidents of math and science. He/she will lead the club members in the outreach activities with the other club officers. He/she will work closely with the staff and mentors to ensure planning takes place for each meeting.
- Secretary of Outreach will document the officer's planning meeting with minutes and track attendance of the officers. He/she will provide schedules whenever needed. He/she will support the VP of Outreach in coordinating schedules by working closely with the secretaries of science and math. He/she will present the minutes of the meeting to the administration and mathematics and science department chairpersons.
- Students who come from feeder schools with a Math and science club are automatically members.

APPENDIX D
Research Projects 2011-2012

D1. Salmon Roe DNA Show a Promising Material for Electronic and Photonic Applications by Takeisha Hankins, 12th grade

Figure D-1 Salmon Roe

D1.1 Introduction

Salmon Deoxyribonucleic Acid; a promising material has been identified for optical, electro-optical memory, and optical amplifier applications. DNA from the salmon roe appears to be a stable material at high temperatures with no visible degradation of films up to 200 degrees Celsius. Salmon DNA has the potential to enhance chromophore alignment in poled polymer applications.

D1.2 Technical Discussion

D1.2.1 Who Discovered DNA?

Gregor Mendel preformed an experiment in 1857 that led to increased interest in the study of genetics. The greatest experiment that Mendel performed involved growing thousands of pea plants for 8 years. In 1928 a scientist named Frederick Griffith was working on a project that enabled others to point out that DNA was the molecule of inheritance. Griffith's experiment involved mice and two types of pneumonia, a virulent and a non-virulent kind. Fourteen years later a scientist named Oswald Avery continued with Griffith’s experiment to see what the inheritance molecule was. In this experiment he destroyed the lipids, ribonucleic acids, carbohydrates, and proteins of the virulent pneumonia. Transformation still occurred after this. Next he destroyed the deoxyribonucleic acid. Transformation did not occur. Avery had found the inheritance molecule, DNA. In the 1940’s another scientist named Erwin Chargaff

noticed a pattern in the amounts of the four bases: adenine, guanine, cytosine, and thymine. He took samples of DNA of different cells and found that the amount of adenine was almost equal to the amount of thymine, and that the amount of guanine was almost equal to the amount of cytosine. Two scientists named, Rosalind Franklin and Maurice Wilkins, decided to try to make a crystal of the DNA molecule. If they could get DNA to crystallize, then they could make an x-ray pattern, thus resulting in understanding how DNA works. These two scientists were successful and obtained an x-ray pattern. The pattern appeared to contain rungs, like those on a ladder between to strands that are side by side. It also showed by an “X” shape that DNA had a helix shape. In 1953 two scientists, James Watson and Francis Crick, were trying to put together a model of DNA. When they saw Franklin and Wilkin's picture of the X-ray they had enough information to make an accurate model. They created a model that has not been changed much since then. Their model showed a double helix with little rungs connecting the two strands.

Structure of DNA $\longrightarrow$ (Carries hereditary information)

DNA is double helix

Figure D-2 DNA Double Helix Structure

Paired Bases

- Thymine
- Adenine

Are connected by two hydrogen bonds

- Guanine
- Cytosine

Are connected by three hydrogen bonds

The only difference between person to person DNA is that it is replicated different.

D1.3 Salmon DNA Points the Way to Green Electronics

Salmon fishing is a very large industry in Hokkaido, Japan some 200,000 tons per year. The male roe is normally a waste product but it is very rich in DNA. DNA is normally soluble in water making it very difficult to process into thin films. A reaction with a surfactant to converts the DNA into water insoluble in selected alcohols.

D1.3.1 What is a Chromophore?

A chromophore is the part of a molecule responsible for its color. The color arises when a molecule absorbs certain wavelengths of visible light reflects others?

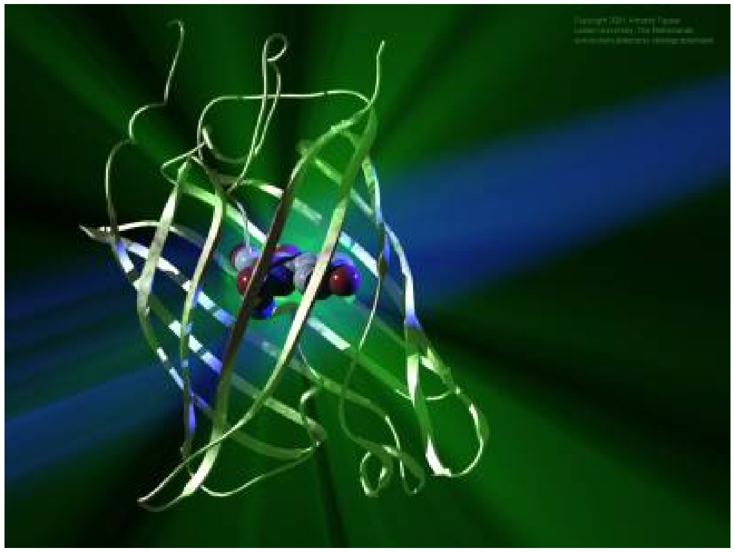

Figure D-3 Chromophore Light Reflection

D1.3.2 Why use DNA from Salmon Roe?

DNA from salmon Roe show unique optical and electromagnetic properties, including low and tunable electrical resistivity, and ultralow optical and microwave loss. Organic field effect transistors, organic light-emitting diodes, and nonlinear optical polymer electro-optic modulators fabricated from this new biopolymer have demonstrated performance that exceeds that of state-of-the-art devices made with currently available organic-based materials. In addition to its unique electromagnetic and optical properties, the DNA-based biopolymer is abundant, inexpensive, replenish able, and composed of green materials. A variety of agricultural waste products can be used as raw materials, and because the biopolymer is not fossil fuel-based, it will not deplete natural resources or harm the environment. Currently available polymer materials either have low optical loss and high electrical resistivity or low electrical resistivity and high optical loss. This material has been found to have high thermal stability up to a temperature of 230°C, and it maintains its double-helical structure to temperatures in excess of 100°C. The electrical resistivity measures three to five orders of magnitude lower than that of other polymer materials, and its optical and microwave losses are an order of magnitude lower. These characteristics make the biopolymer very attractive for electro-optic devices.

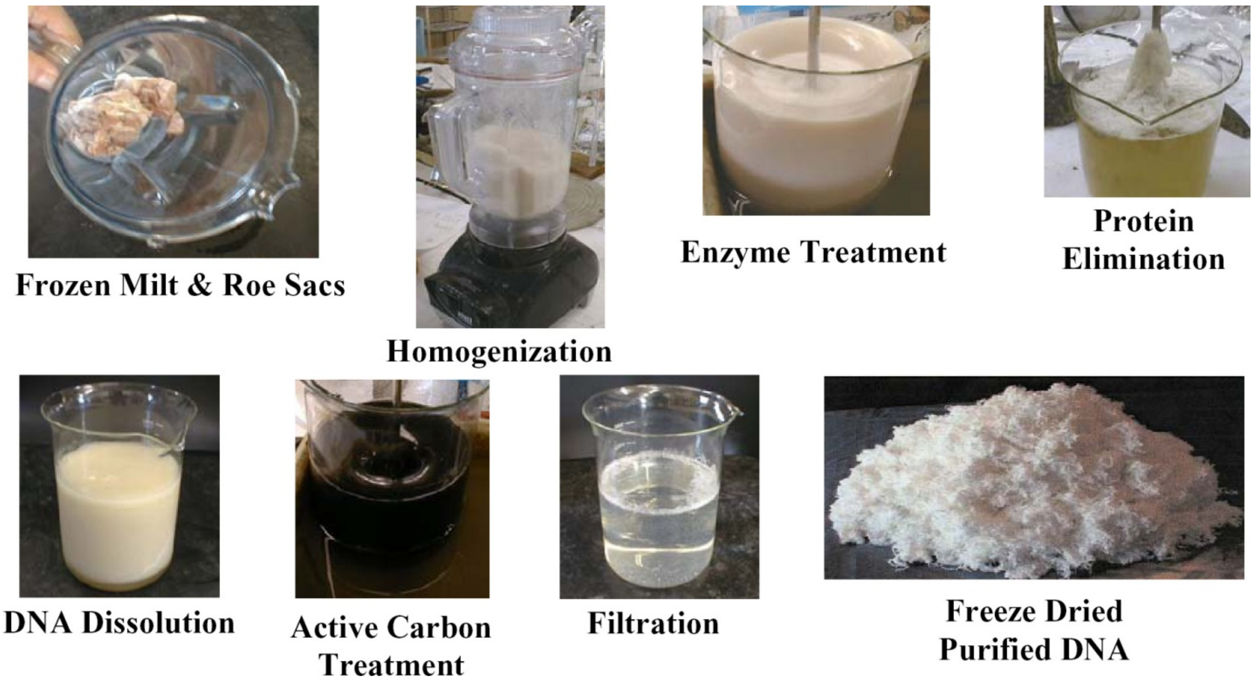

Figure D-4 Materials

D1.3.3 What is an Organic Solvent?

Organic solvents are substances that are capable of dissolving or dispersing one or more other substances. Organic solvents are carbon solvents they contain carbon in their molecular structure. It's a liquid organic compound with the power to dissolve solids, gases, or liquids for example methyl and Butanol alcohol. One organic solvent that is commonly used in making the films is Butanol. Butanol is a flammable liquid that is used as a fuel and as an industrial solvent. It is a hydrocarbon, meaning it is composed of the chemical elements hydrogen, oxygen and carbon.

D1.3.4 What are Bio-LEDS?

Bio LED's are semiconductor polymers with tunable optical properties located on either side of a microfluidics chip. One film illuminates the chip, where appropriate, while the other film detects an output signal, which is fed to a display. The demonstrated device used two forms of detection utilizing chemiluminescence and fluorescence to detect different markers of interest.

Figure D-5 Salmon DNA Enhanced

D1.4 References

The race to find the mystery: The structure of DNA
http://www.ceoe.udel.edu/extreme2004/genomics/dnahistory.html Copyright University of Delaware, November 2004
Salmon DNA Points the Way to Green Electronics
http://www.sciencedaily.com/releases/2007/09/070913132937.htm *Copyright © 1995-2010 Science Daily*
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(Received 5 September 2005; accepted 6 October 2005; published online 17 November 2005)
Marine-based deoxyribonucleic acid (DNA), purified from products of the Japanese fishing industry, has recently become a material of interest in photonics applications. Using highly purified DNA, unique processing technique developed specifically to transform the purified DNA into a biopolymer suitable for optical device fabrication are reported)
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D2. String Sympathy by Chris Ray, 12th Grade, Thurgood Marshall High School

D2.1 Abstract

Question: Which musical intervals (spaces between notes) are most effective at producing sympathetic vibrations?

Hypothesis: If all the frets of each string on a guitar are strung, then the middle of the guitar (on a 24-fret guitar, approximately the 11th or 12th fret) will be the most effective at producing sympathetic vibrations because the middle of the string is the part where the string has the most buoyancy.

I got this idea by trying to think of creative ways to conduct a science fair project that dealt with guitars. I think the work is interesting because not only do I have interest in guitars, which is what made me choose the topic, but also because music is something that is generally enjoyed by all audiences. When I started this project, I hoped to put together a science fair project related to guitars that is both interesting and complex, and would prove to be a worthy contender in the state science fair.

D2.2 Background

There are six strings on a guitar, each with open notes of E_2, A_2, D_3, G_3, B_3, and E_4, each with corresponding frequencies of 82 Hz, 110 Hz, 147 Hz, 196 Hz, 247 Hz, and 330 Hz (Fletcher 207). These frequencies represent the root tone of each string. What makes a guitar sound the way it does is the overlay of various frequencies on each string, or the overtones present. These patterns of overtones and their strengths are what make a guitar sound different from say, a trombone. In addition, this exact patterns of overtones is impossible to repeat, and so every instrument will sound different, and in fact every note as subtly changes from the exact location on the string where it is plucked to the force, direction, and the age of the string both off and on the guitar all have small effects on the sound.

These strings then transfer their sound into the body of the guitar where they set up an internal resonance in the air chamber made by the body, and cause the back plate and face plate to vibrate. These vibrations cause the air to compress and rarify making the compression waves in the air that our ear interprets as sound. For a more complex discussion of these parts, see how the guitars strings, body, or the space between them works (ffden-2.edu).

Sounds are "communicated" when they are merely conveyed from one sounding body to another, and this can take place in a noise as well as a musical sound. Sounds are "excited" under two circumstances: when a body which is sounding and that to be excited have the same note and the vibration of one produces **sympathetic vibration** of the other, the bodies are mutually called "reciprocating", while of the vibration of one produces its harmonics in the other, the latter is said, with regard to the exciting body, to be "resonant" (pondscienceinstitute.com).

These sources explain the general concept of my experiment; one source details the characteristics of a guitar body, while the other describes the physics of sympathetic vibration.

D2.3 Experiment

D2.3.1 Materials and Equipment

- An acoustic guitar, properly tuned
- Guitar pick
- A quiet room
- Lab notebook
- Pen or pencil

- Optional, but helpful: an electronic tuner

D2.3.2 Procedure

1. The experiment must be done with a guitar that is in tune, so start out by tuning the guitar (if you're not an experienced guitarist that can tune by ear, this is where the tuner comes in hand)
2. The experiment must be done in a quiet room, where you can hear the guitar without a lot of background noise.
3. Pluck the open high E string, then immediately mute it (touch it with your finger to stop it from vibrating).
    a. Listen carefully, and you should hear that the guitar is still making sound from sympathetic vibrations of one or more of the other five strings.
    b. Determine which strings are sympathetically vibrating by muting the other strings, one by one.
4. Listen carefully to how the sound changes as you mute each string. Then, answer the following questions (you will have to repeat the procedure several times to confirm your observations):
    a. Which string(s) contributes the *most* to the remaining sound after you mute the string that was plucked?
    b. Which string(s) contributes the *least* to the remaining sound after you mute the string that was plucked?
5. Now fret the high E string just behind the first fret. Pluck the string again and immediately mute it.
6. Repeat the observations made in steps 4 and 5. The procedure must be repeated (fret the string, pluck it, mute it) several times in order to confirm your observations.
7. Repeat steps 6 and 7 for frets 2–12.
8. Organize the data in a table like the one below:

Plucked string (E, A, D, G, B, or e)	Fret (1–12)	Sympathetic vibrations? (y/n)					
		E	A	D	G	B	e
etc.							

9. Identify any patterns in your data. For example, which note intervals produce sympathetic vibrations most often?

D2.4 Discussion

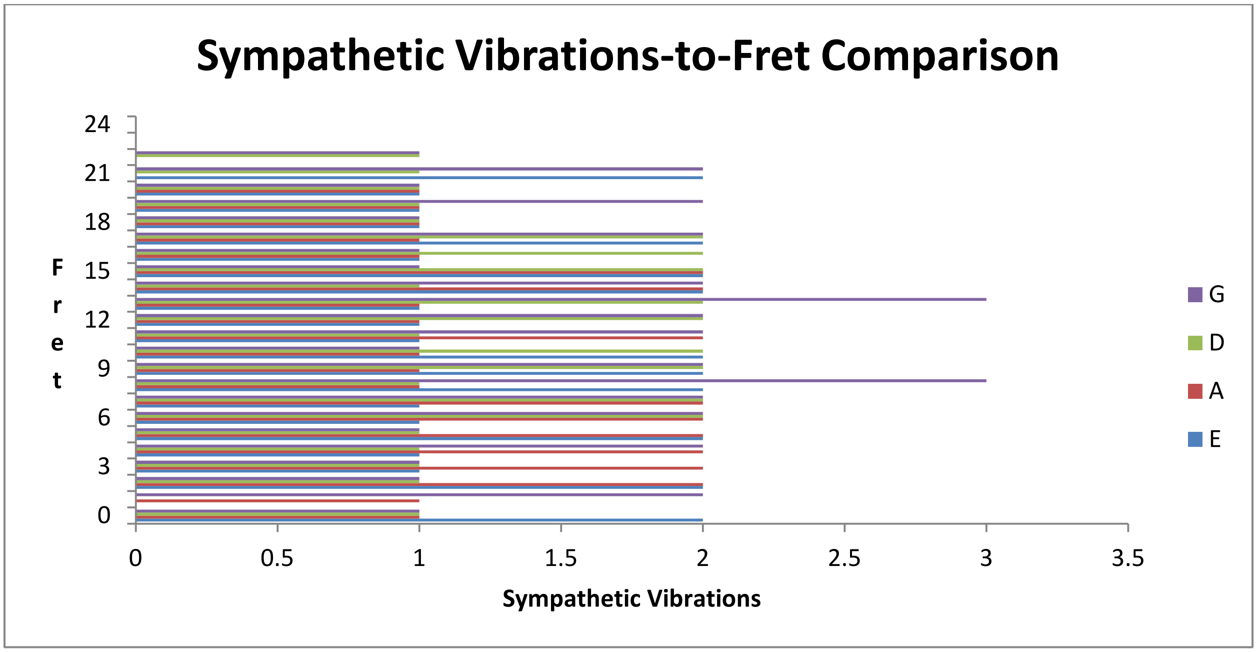

Figure D-6. Sympathetic Vibrations-to-Fret Comparison

After conducting the experiment and recording the results, I looked to see where sympathetic vibrations occurred the most, which strings had the most, and which had the least. I look at which string had the most "Y's" or "√'s", which identifies which one vibrated the most when other strings were plucked. The string with the most "N's" or X's" denotes the string that vibrated the least amount of times when other strings were plucked. Also, along the strings, the frets represent different segments of the string. Some segments of the string when plucked produced multiple sympathetic vibrations, so I checked which frets had acquired the most of them.

The trend of the data is direct. It raises, peaks in the middle, and then gradually decreases. The mathematical model represented by a graph of my data is the Gaussian function or "bell curve" (normal distribution).

If I were to do this project again, I would try to use a piano instead of a guitar to see if the results would be similar.

D2.5 Conclusion

From my results, it is found that my hypothesis was true; the middle of the guitar produced the most sympathetic vibrations. The average fret that had the most sympathetic vibrations is the 11th fret, which was the prediction in my hypothesis.

Notable trends that are also concluded from the experiment are: the end of the strings (frets 22-24) seemed to produce little to no sympathetic vibrations, string G produced the most sympathetic vibrations (most likely due to it being the thickest and heaviest string) and sympathetically vibrated the least, and that string E sympathetically vibrated the most (most likely due to it being the thinnest and lightest string, easily being moved).

D2.6 References

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D3. Temperature Impacts on Computer Performance, Jasmin Sanford, Grade 10

D3.1 Abstract

In this project, the temperature of two types of computers will be investigated. The speed of the select program will also be tested. The objective is to find out whether a program will run faster depending on the temperature of the CPU of a desktop or laptop. If the surface, that the computers are tested on, supplies better ventilation then the desktop will have a cooling advantage when tested on the carpet because, most laptops' air vents are located on the bottom of it. This investigation first became interesting when an opportunity for an after school computer basics program became available. The reward of that besides computer experience was to be able to keep it. Computer experience was also obtained from my father who is an IT systems engineer. Testing of the temperature of the CPU will occur over a five-hour period. Testing how long it takes for the program to open, and recording the results will be recorded in a table and graph. Materials needed for this project are a desktop computer, laptop computer, stopwatch, and computer knowledge. A few of the independent and dependent variables in this investigation are; how hot the CPU gets, the temperature of the CPU, and how fast the fan can cool off the CPU. The constant variable is the testing time (by the hour); in this investigation. It was discovered that a program ran faster on a laptop than on a desktop while on the table the desktop worked better on the carpet.

D3.2 Introduction and Background

This project is about the effect of the CPU over a running program. The purpose of this investigation is find out whether a program will run faster on a desktop or laptop according to the temperature of the CPU. If the surface, that the computers are tested on, supplies better ventilation then the desktop will have a cooling advantage when tested on the carpet because, most laptops' air vents are located on the bottom of it. The laws of thermodynamics will be included to determine the difference between the heat from the processor and the battery in a laptop and desktop. The average temperature of a CPU will be visited when addressing the anticipated temperature range and cooling time for the computers.

There are three levels of processor cooling systems.

- The lowest level is heat sink.
    - Heat sink transfers heat away from the CPU with high heat, to the heat sink with lower heat, but with higher heat capacity
    - A heat sink will cool your CPU on its own, but having good air flow will greatly increase the rate at which it can cool your processor.
- The next level of cooling is water cooling.

- The base, which sits over the top and is in contact with the CPU, and the "top", which ensures that the water stays safely contained, the base is usually made from copper or aluminum, or a mixture of both.
  - The top of the water block will have two hose connections, one inlet and one outlet, water comes in through the inlet connection, flow through the water block and pick up the heat off the CPU.
- The highest level of cooling is thermo electrical cooling.
  - It can get below ambient temperatures, less expensive and more compact than other types of extreme CPU cooling
  - Uses high power, condensation can form on CPU when temperatures drop below ambient.
- The average computer temperature depends on your room temp and the size of the heat sink and fan on the processor.
- The average temperature of a laptop is 45degrees Celsius, the minimum is about 36C,the maximum temp of the CPU is 99C
- Speed of a processor depends on the clock rate and the instructions per clock (IPC), which together are the factors, for the instructions per second (IPS) that the CPU can perform. Many reported IPS values have represented "peak" execution rates on artificial instruction sequences with few branches, whereas realistic workloads consist of a mix of instructions and applications, some of which take longer to execute than others.(wikipedia.com)
- The CPU processes all the information received either by internal or external input devices.
- When information is entered via the keyboard (external) the processor sends that data to the memory and that is processed through computer programs such as Word and Excel and is displayed on the screen (output) or the printer (input)
- The larger a CPU (GHz or MHz) the less heat generated over a period of time.(answers.com)
- An Intel core 2 duo has an average CPU clock rate of 1.06GHz-3.33GHz.
- An Intel Celeron has an average CPU clock rate of 266MHz-3.6GHz
- An Intel core 2 duo has an average FSB of 533MHz-1600MHz
- An Intel Celeron has an average FSB of 66MHz-1066MT/s
- FSB is the front side bus which carries data between the CPU and the northbridge.
- Northbridge is one of two of the chips in the core logic chipset on a PC motherboard (northbridge.com)

D3.3 Technical Discussion

The objective is to find out whether a program will run faster depending on the temperature of the CPU of a desktop or laptop. If the surface, that the computers are tested on, supplies better ventilation then the desktop will have a cooling advantage when tested on the carpet because, most laptops' air vents are located on the bottom of it. In this project the independent variables will be the fan (cooling) and current flow (heating).

The dependent variables are the temperature (heat and cooling) of the CPU's. (Celsius)

The constant variable is the total time of operation. (Per hour)

D3.3.1 Methods and Materials

1. Test desktop and laptop temperatures when it's been first turned on.
2. Open select program and record how long it takes to open
3. Repeat process for four more consecutive hours

D3.3.2 Materials used in this investigation are

1. Desktop computer
2. Laptop computer
3. Stopwatch

D3.4 Results and Data

The CPU in the desktop is an Intel Core 2 Duo, and for the laptop there is an Intel Celeron. Both the desktop and laptop CPU's uses heat sink as its cooling system. The desktop fan is about $16in^2$, while the laptop fan is about $25in^2$. The desktop and laptop will be tested on both the carpet and the table. The laptop heated up more than the desktop when tested on the carpet because the carpet prevented the heat from escaping the computer. The desktop has a cover with vents on the side which allows the heat to escape. The laptop was cooler on the table then the desktop.

Table D-1 Tested on a Table

Hour	Desktop CPU Temperature	Laptop CPU Temperature	Desktop opening time	Laptop opening time
1	28C	28C	25s	26s
2	34C	32C	55s	35s
3	45C	48C	1:05min	47s
4	61C	72C	57s	49s
5	74C	86C	59s	52s

Table D-2 Tested on a Carpet

Hour	Desktop CPU Temperature	Laptop CPU Temperature	Desktop opening time	Laptop opening time
1	28C	28C	30s	29s
2	36C	39C	35s	48s
3	44C	51C	45s	55s
4	66C	74C	57s	58s
5	79C	89C	1:00min	1:07min

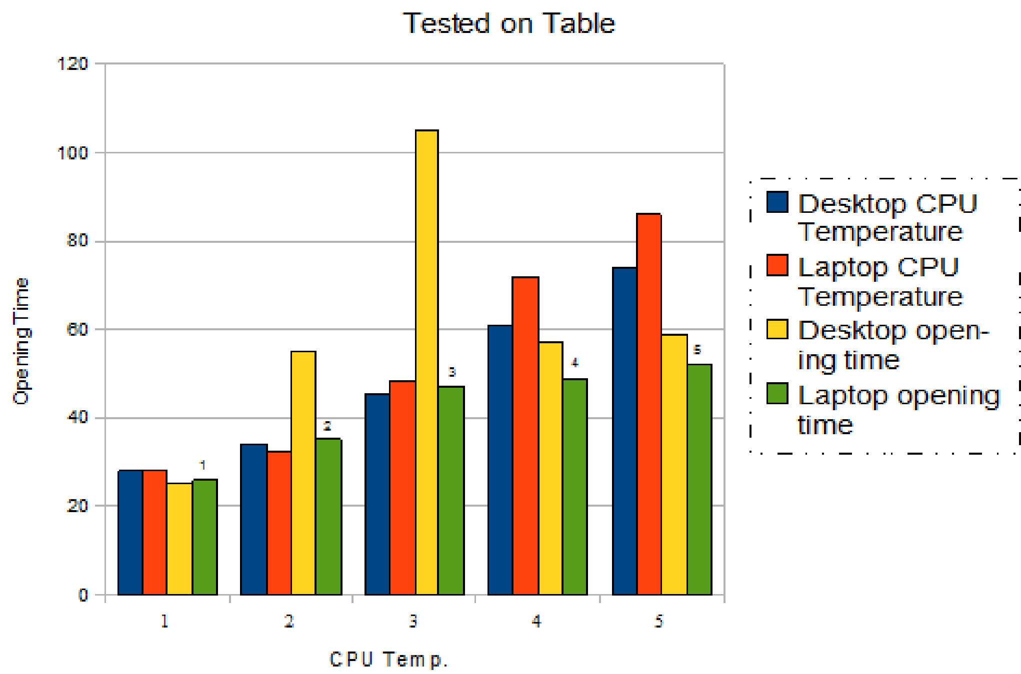

Figure D-7 Tested on a Table (Temperature)

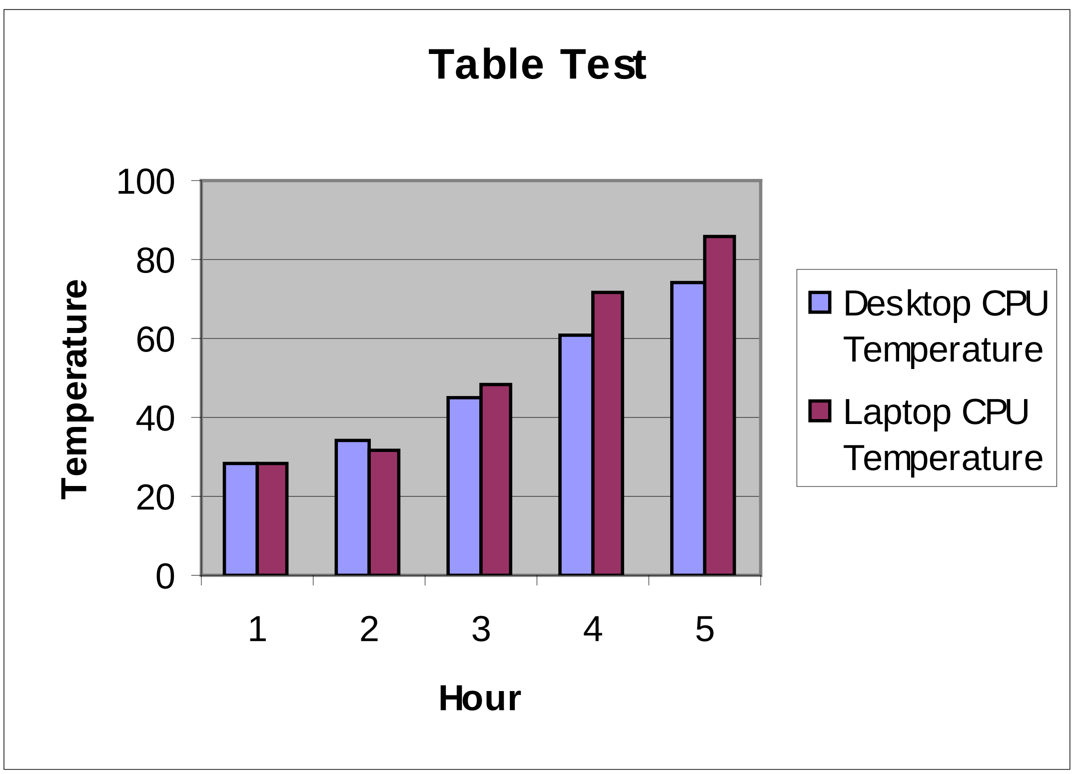

Figure D-8 Tested on a Table (Hours)

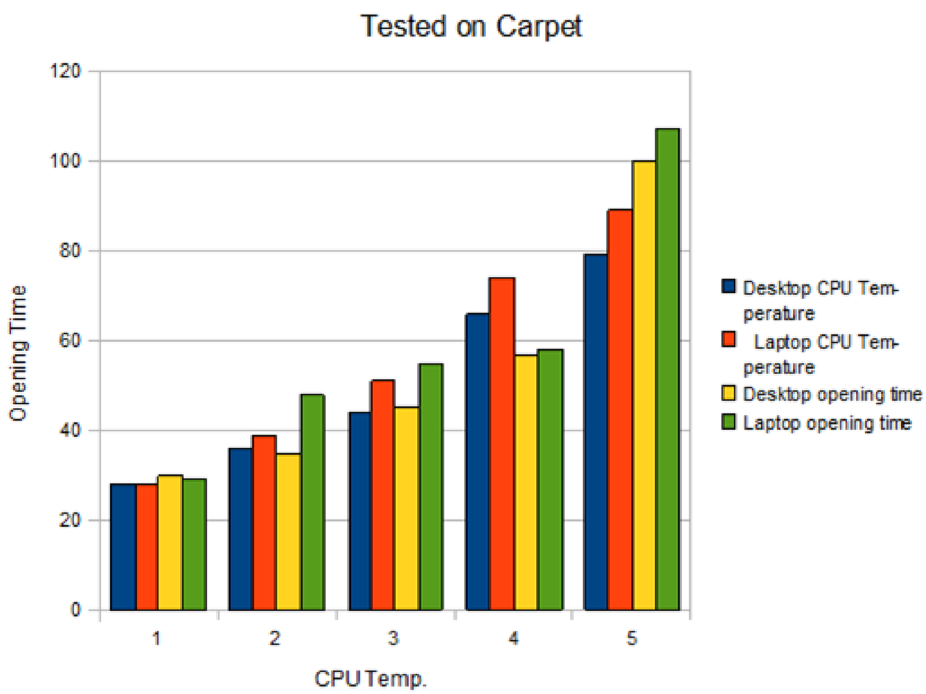

Figure D-9 Tested on Carpet (Temperature)

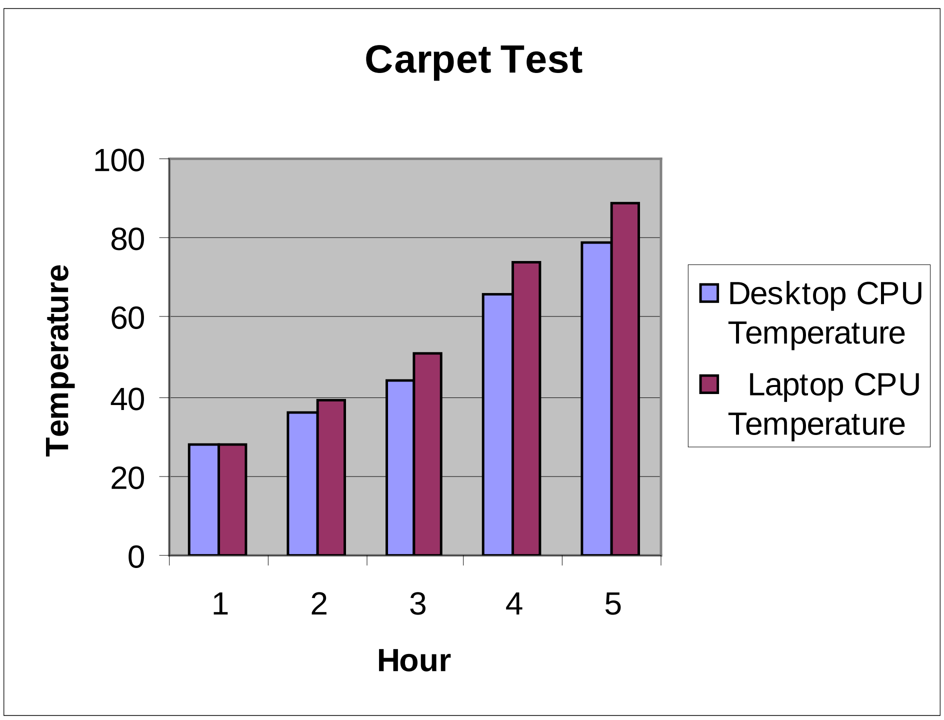

Figure D-10 Tested on Carpet (Hours)

D3.5 Discussion and Conclusion

Most laptops use air cooling in order to keep the CPU and other components within their operating temperature range. Because the fan's air is forced through a small port, the fan and heat sinks can be clogged by dust or be obstructed by objects placed near the port. This can cause

overheating, and can be a cause of component failure in laptops. The severity of this problem varies with laptop design, its use and power dissipation. With recent reductions in CPU power dissipation, this problem can be anticipated to reduce in severity. CPUs were custom-designed as a part of a larger, sometimes one-of-a-kind computer. This standardization trend generally began in the era of discrete transistor mainframes and minicomputers. Both the miniaturization and standardization of CPUs have increased the presence of these digital devices in modern life far beyond the limited application of dedicated computing machines. The desktop works better on a carpet than the laptop due to the air vents being covered. The hypothesis was correct because the desktop had an advantage on the carpet test due to the cover and the laptop's air vents being covered.

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c. *Upgrading & fixing laptop for Dummies:* Corey Sandler © 2006

d. *Upgrading & fixing PCs for Dummies: Andy Rathbone © 1998*

e. www.tech-faq.com

D4. How accurate are pictures? More Valid than words? By Eliza Straughter, 12th grade, Thurgood Marshall High School

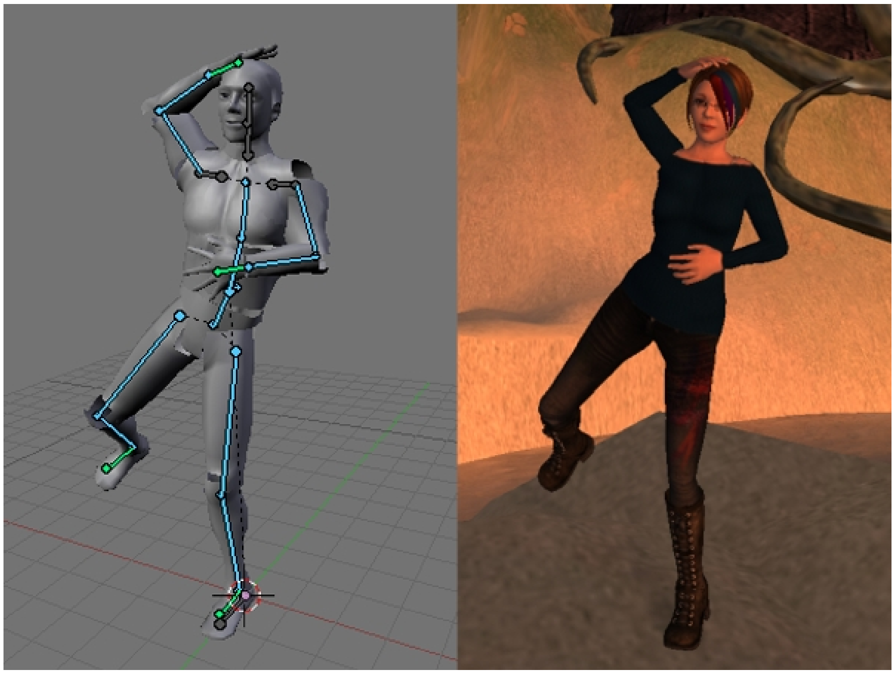

Figure D-11 How Accurate Are Pictures – More Valid than Words?

D4.1 Abstract

The objective of this experiment is to determine if the number of pixels in a real world image can be detected even as the distance changes. If this is true, the next thing we want to determine is will the virtual world image can accurately reflect the real world image. Another question that needs to be answered is can tools like Blender offer enough realism to generate valid data that can be used in Layered Sensing experiments. This will be done by studying how the pixel size and the focal length differ in the real world and in the virtual world. The reason for comparing them is to try to determine how accurately the software tools are viable for computer vision research. I also want the ability to use a computer generated model so the camera position (x, y, z), light position (x, y, z), and light brightness can be perfectly controlled in order to visualize how to arrange my image similar to the original photo. The plan is to understand the researcher's reason for using this kind of software as well as to discover whether or not its design is based upon the same optics and invariant properties as the original picture taken.

D4.2 Introduction

In this experiment, two realms will be tested: the real word and animation rendering software program (Blender). In the real world, the basic things you can control are camera position, camera attitude, and some basic brightness. When capturing a picture in the real world, many things affect it; one is the lighting. The place in which the lighting is located affects all reflection as well as visual contrast. What will be tested here is to see how accurately the virtual worlds mirror the real world.

Blender is a 3D graphics application that can be used for modeling, UV unwrapping, texturing, rigging and creating interactive 3D applications including animated film and visual effects. Blender's features include advanced simulation tools such as rigid, realistic body, fluid, modifier-based modeling tools, powerful character animation tools, a node-based material and compositing system and Python for embedded scripting. Blender is written in C, C++, and Python computer programming languages and it is compatible with most operating systems like Microsoft Windows, Mac OS X, Linux, etc. Blender is a dominant open source product with a range of features comparable to mid- to high-range commercial, proprietary software. Blender also started out as an in-house tool for a Dutch commercial animation company, NeoGeo. Now Blender has been used for television commercials in several parts of the world like Sydney, Australia and Brazil. The first large professional project that used Blender was *Spider-Man 2*, where it was primarily used to create pre-visualizations for the storyboard department.

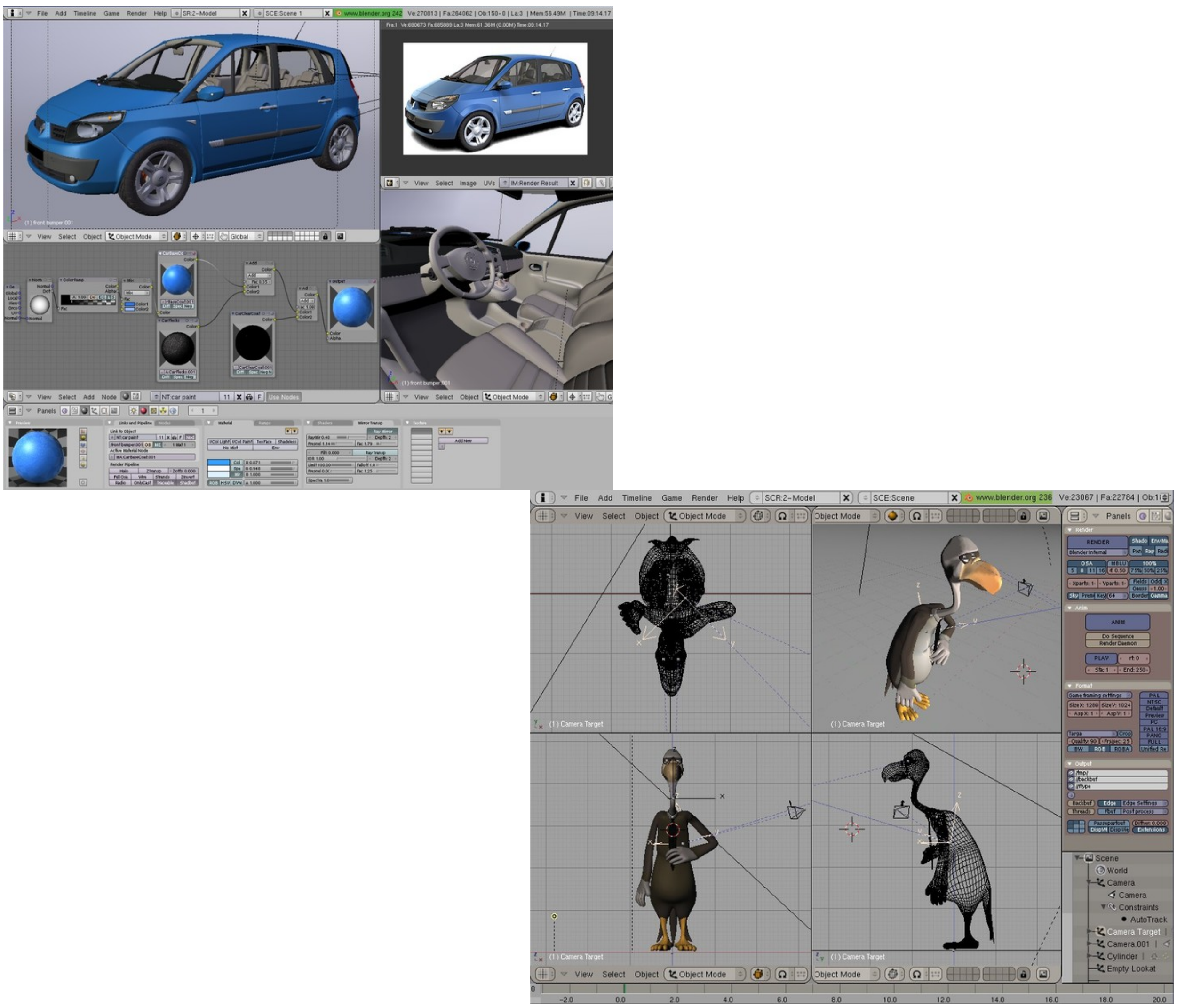

Figure D-12 Blender Sample Screen Shots

In the case of the Air Force Research Laboratory, where I work in the summer as an intern in the Sensors Directorate, they would like to use Blender for simulation because it is expensive to fly aircraft as often as they need to. Moreover, a simulation system could be used for experiments to fly multiple aircraft for Layered Sensing research.

Layered Sensing provides military and homeland security decision makers at all levels with timely, actionable, trusted, and relevant information necessary for situational awareness to ensure their decisions achieve the desired military effects. Layered Sensing is characterized by the appropriate sensor or combination of sensors/platforms, infrastructure and exploitation capabilities to generate that situation awareness and directly support delivery of "tailored effects". This construct will serve AFRL extremely well as it transforms its focus and research programs to successfully tackle some of the most complex technological problems facing the U.S. today. Layered sensing implies that multiple aircraft with multiple sensors will be deployed at the same time in a series of "layers". Determining how many aircraft and what type of sensors is an on-going research area for the Sensors Directorate in AFRL. The Sensors Directorate has a vast team of researchers from high school (like me) to world class PhD's and they can't afford to give all the researchers aircraft and sensors. One of the key questions I would like to answer with this research is can tools like Blender offer enough realism to generate valid data that can be used in Layered Sensing experiments?

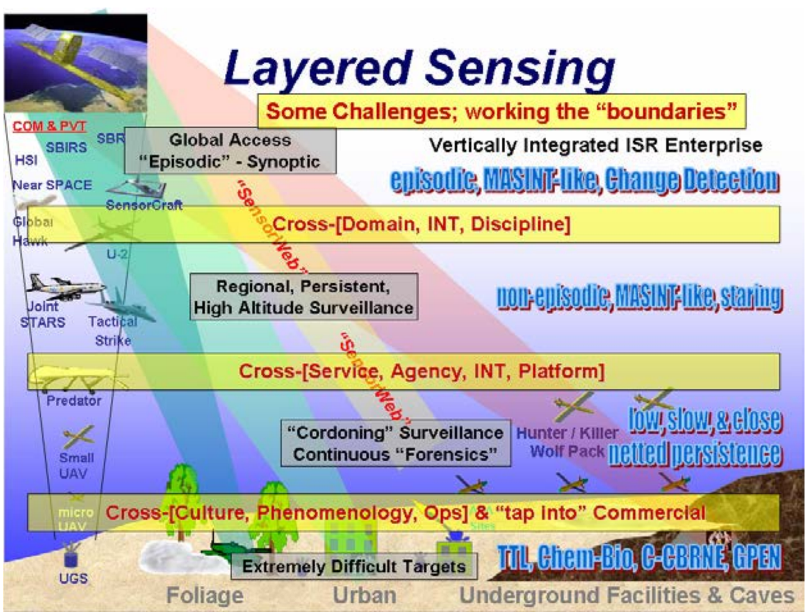

Figure D-13 Layered Sensing Chart

If tools like Blender become research enabling tools, they will have the ability to roam environments that we can't normally go to like Baghdad, Kandahar, North Korea, etc. Below are pictures rendered in Blender of Sadr City in Iraq.


Figure D-14 Picture 1 Rendered in Blender of Sadr City in Iraq

Figure D-15 Picture 2 Rendered in Blender of Sadr City in Iraq

Sadr City is one of the poorest areas in Baghdad where unemployment is rampant. Homes are in disrepair and Sadr City is a haven for criminals released from Iraqi prisons by Saddam shortly before the start of Operation Iraqi Freedom. While Sadr City has obvious interest to the US Military and is a prime location to conduct Layered Sensing experiments it is not a safe location to send researchers. Software like Blender has the capability to put the researcher in any environment they require with the capability to script the movement of vehicles and even people. The question is for a researcher: if you use a tool like Blender, is it good enough to call the research valid?

My hypothesis will be tested by studying a field called optics. Optics is a branch of physics which involves the behavior and properties of light, including its interactions with matter and the construction of instruments that use and/or detect it. The optics of photography involves both lenses and the medium in which the electromagnetic radiation is recorded, whether it be a plate, film, or charge-coupled device.

Another argument that must be addressed is how a real image differs from a virtual image, based upon the laws of optics. In optics, a real image is a representation of an actual object (source) formed by rays of light passing through the lens. A real image is the image obtained on a cinema screen. If we observe an image on a screen inside or behind a converging lens, what we see on the screen is a real image because the image really is at the screen's location. Real rays of

light are always represented by full, solid lines. A real image occurs where rays converge, whereas a virtual image occurs where rays only appear to converge.

When we see through a lens or a mirror, what we see is not a real image. This, the image that we see on the other side of the lens or mirror plane, is known as virtual image. In optics, a virtual image is an image in which the outgoing rays from a point on the object never actually intersect at a point. A simple example is a flat mirror where the image of oneself is perceived at twice the distance from you to the mirror. That is, if you are half a meter in front of the mirror, your image will appear at a distance of half a meter inside or behind the mirror. When we look through a diverging lens or look into a convex mirror, what we see is a virtual image.

The device that will be used to capture the images will be a 35 mm film. This film is the basic film gauge used most commonly used for still pictures. The photographic film is cut into strips 35 millimeters (hence the name). The gauge is remarkably versatile in application. In the past one hundred years, it has been modified to include sound, redesigned to create a safer film base, formulated to capture color, has accommodated a bevy of widescreen formats, and has incorporated digital sound data into nearly all of its non-frame areas.

Another key term needed for this experimentation is ray tracing. Ray tracing is a technique for generating an image by tracing the path of light through pixels in an image plane and simulating the effects of its encounters with virtual objects. The technique is capable of producing a very high degree of visual realism, usually higher than that of typical scan line rendering methods, but at a greater cost. This is why it is thought that Blender will have some accuracy because it focuses more on the rendered image quality rather than its speed. Blender has the ray tracing capability because it is more likely to observe ray tracing in applications that are used for film and television.

Another operation that plays a huge part in the optics of photography is the image's focal length. The focal length of an optical system is a measure of how strongly a system focuses on light. In photography, longer focal length or lower optical power brings upon larger magnification of distant objects, and a narrower angle of view. Shorter focal length or higher optical power leads to a wider angle of view.

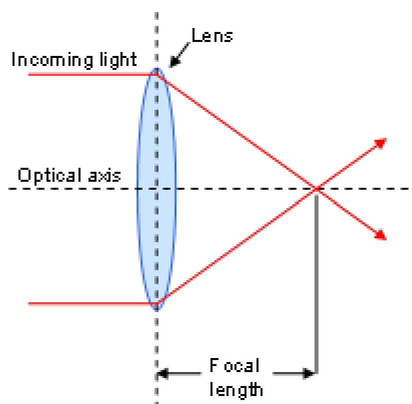

Figure D-16 Angle of View from Shorter Focal Length or Higher Optical Power

The focal length of a lens determines the magnification at which it images distant objects. It is also equal to the distance between the image plane and a pinhole that displays distant small objects the same size as the lens in question. To render closer objects in sharp focus, the lens must be adjusted to increase the distance between the rear nodal point and the film, to put the film at the image plane. A cool fact to note is that when adjusting the camera's distance from the

main subject while changing focal length, the main subject can remain the same size, while the other objects in the area at a different distance changes size.

Perspective distortion is another topic to focus on within this experimentation. Perspective distortion is the wrapping and transformation of an object and its surrounding area that differs significantly from what the object would look like with a normal focal length, due to the relative scale of nearby and distant features. Perspective distortion is determined by the relative distances at which the image is captured and viewed, and is due to the angle of view of the image (as captured) being either wider or narrower than the angle of view at which the image is viewed, hence the apparent relative distances differing from what is expected. Note that the perspective distortion is caused by distance. Two shots of the same scene from the same distance will exhibit identical perspective distortion, regardless of lens used. However, since wide-angle lenses have a wider field of view, they are generally used from closer, while telephoto lenses have a narrower field of view and are generally used from further away.

All in all, for this experimentation, it is hypothesized that if a 3D model of a real world picture is taken in a virtual world (Blender) using algorithms, virtual cameras, and physics of optics, then compared to the 35mm photo it will be similar but not accurate because most gaming systems avoid ray tracing which forces the lens to miss the focal point; differing the image from the original 35mm photo.

D4.3 Technical Discussion

In order to conduct the experiment, a few things are needed: computer that is compatible with Blender and Blender software pre-downloaded and approved, a few wooden blocks of various sizes, primary paint colors for the blocks, a black carpet and/or black backdrop, a 35mm camera and a tripod. First, the research must revisit the principles of optics as well as practice tutorials on pinhole cameras, concave lenses, and convex lenses. Next, find a few solid, wooden blocks and paint them in solid colors and then take measurements on the blocks in order to design very similar, virtual shapes. Then place the painted shapes on a black background and platform and place a 35 mm camera on a tripod about 10 feet away from the blocks and take a few photos. Do this two more times but with the camera being 15 and 20 feet away. Upload these photos to a pc and determine the pictures focal length, pixel dimensions, and f-stop. With this information, you should be able to determine the number of pixels that are inside the picture (below is a table containing this information). Then, after learning how to operate Blender, design the same shapes to scale in the virtual worlds. From there, pixel sizes, ray tracers, and the varying focal lengths must be compared in order to determine the accuracy of the two virtual images.

Table D-3 Number of Pixels Inside Blender Picture at 5 Feet

Variable Name	Value	Unit
f(Focal Length)	0.311023622	inches
Z (Distance)	60	inches
Y (Green Block Height in RL)	4	inches
X(Green Block Width in RL)	2	inches
y (Green Block Height in IP)	0.020734908	inches
x(Green Block Width in IP)	0.010367454	inches
Pixel Width	2592	pixels
Pixel Height	1944	pixels
Sensor Width	0.282677165	inches
Sensor Height	0.209448819	inches
Pixel Width	0.000109058	inches
Pixel Height	0.000107741	inches
Number of Pixels Horizontally	95.06406696	pixels
Number of Pixels Vertically	192.4511277	pixels

Table D-4 Table D-3 Number of Pixels Inside Blender Picture at 10 Feet

Variable Name	Value	Unit
f(Focal Length)	0.311023622	inches
Z (Distance)	120	inches
Y (Green Block Height in RL)	4	inches
X(Green Block Width in RL)	2	inches
y (Green Block Height in IP)	0.010367454	inches
x(Green Block Width in IP)	0.005183727	inches
Pixel Width	2592	pixels
Pixel Height	1944	pixels
Sensor Width	0.282677165	inches
Sensor Height	0.209448819	inches
Pixel Width	0.000109058	inches
Pixel Height	0.000107741	inches
Number of Pixels Horizontally	47.53203348	pixels
Number of Pixels Vertically	96.22556385	pixels

Table D-5 Table D-3 Number of Pixels Inside Blender Picture at 15 Feet

Variable Name	Value	**Unit**
f(Focal Length)	0.311023622	inches
Z (Distance)	180	inches
Y (Green Block Height in RL)	4	inches
X(Green Block Width in RL)	2	inches
y (Green Block Height in IP)	0.006911636	inches
x(Green Block Width in IP)	0.003455818	inches
Pixel Width	2592	pixels
Pixel Height	1944	pixels
Sensor Width	0.282677165	inches
Sensor Height	0.209448819	inches
Pixel Width	0.000109058	inches
Pixel Height	0.000107741	inches
Number of Pixels Horizontally	31.68802232	pixels
Number of Pixels Vertically	64.1503759	pixels

Table D-6 Table D-3 Number of Pixels Inside Blender Picture at 20 Feet

Variable Name	**Value**	**Unit**
f(Focal Length)	0.311023622	inches
Z (Distance)	240	inches
Y (Green Block Height in RL)	4	inches
X(Green Block Width in RL)	2	inches
y (Green Block Height in IP)	0.005183727	inches
x(Green Block Width in IP)	0.002591864	inches
Pixel Width	2592	pixels
Pixel Height	1944	pixels
Sensor Width	0.282677165	inches
Sensor Height	0.209448819	inches
Pixel Width	0.000109058	pixels
Pixel Height	0.000107741	pixels
Number of Pixels Horizontally	23.76601674	inches
Number of Pixels Vertically	48.11278192	inches

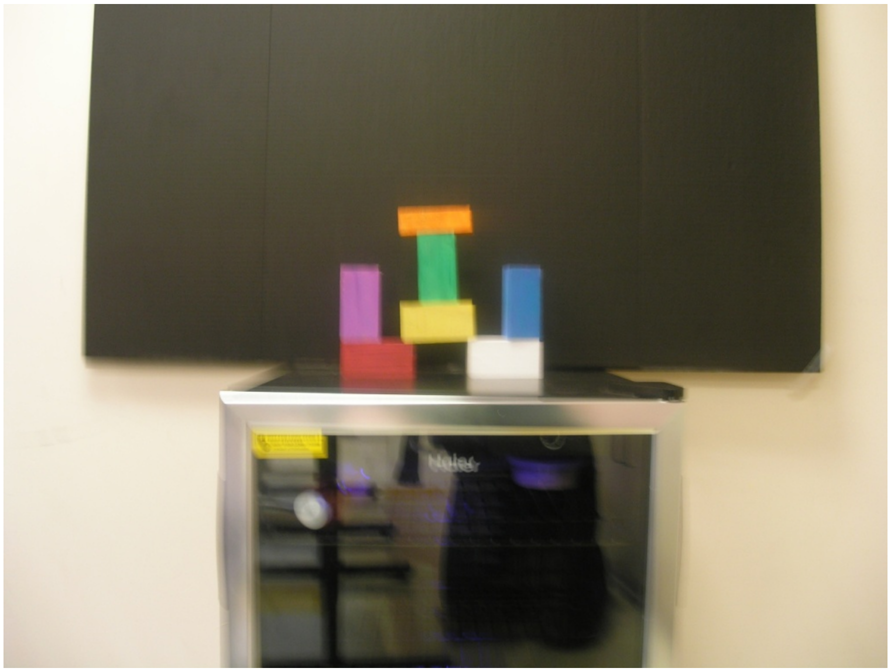

Figure D-17 Real World Picture Rendition

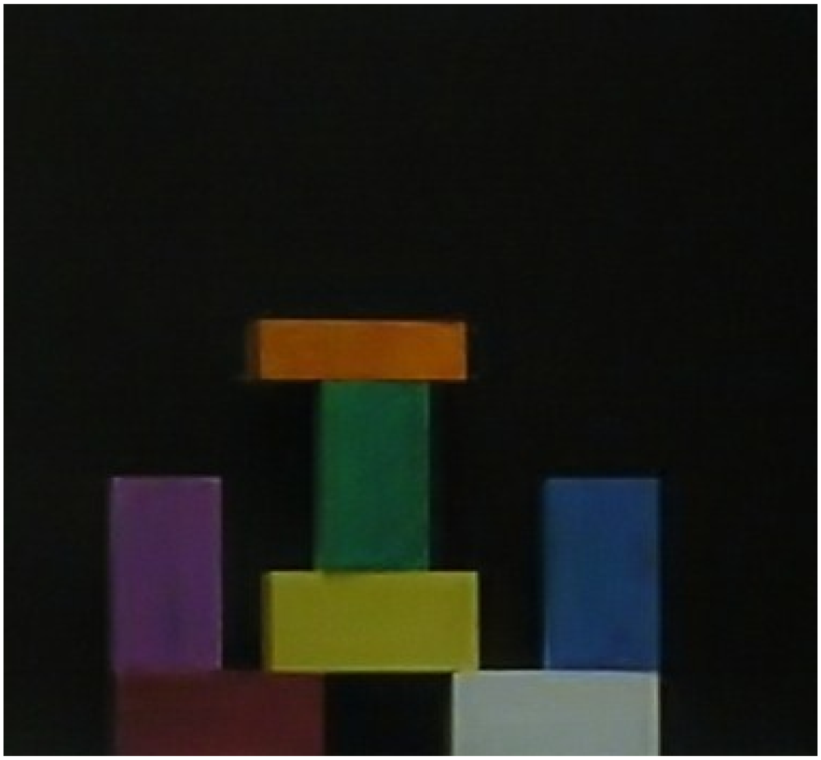

Figure D-18 Virtual World Picture Rendition

D4.4 Conclusion

In conclusion, it was discovered that my hypothesis was proven inaccurate. it was hypothesized that the images would be accurate as the distance changes and that Blender would accurately reflect the real world. This was not completely true because the number of pixels

detected was about 5 pixels off, depending on the distance. It was also discovered that as the distance increased, the number of pixels in the image decreased. That is because as the lens earns more room, the less amount of pixels that must be used in order to form the picture correctly. This was shown correctly in the detection.

Also, in the virtual vs. real scenario, the virtual image is shown to be accurate as far as the human eye can see. However, when calculations are accumulated, there were not enough pixels in the virtual image in order for it to be accurate with the real world.

Lastly, in the case of the AFRL, Blender has enough similarity to the real world to become a research enabling tool and roam over areas like Iraq and Afghanistan. This is because it will only take about 40 pixels to verify that a person or object is in a certain place that it may or may not belong in. Because Blender can account these many pixels and may be only about 5 pixels off, it can become a resource for the Air Force and decrease their amount of spending.

D4.5 Acknowledgements

At this time, I would like to give credit where it is ultimately due. First off, I would like to thank my mentor, Todd Rovito from the AFRL Sensors Directorate, for all of the things he has done for me as a conducted this experimentation. The things he has done I cannot name. I would also like to thank my other mentors from the Air Force Base; Dr. Steven Rogers, Adam Rogers, Matt Kabriski, Christina Schutte, and Christopher Curtis. They have done miraculous things for me throughout this summer and up to today. Next, I would like to think my school mentors Henry Noble and Glenda Konnechy, who have also done many, many things for me throughout the production of this project. Lastly, I would like to thank my mother for her support, guidance, and ability to buy any materials I need.

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APPENDIX E
Overview of Academic Year 2012-2013
Thurgood Marshall High School Math and Science Club

The Thurgood Marshall Math and Science Club meets every Wednesday at 4:00-6:00 PM in Room 1114. The format for every meeting is similar. Prior to Wednesday's Math and Science Club meetings the officers and captains hold a planning meeting.

E1. Weekly Planning Meetings

Planning meetings are held on Mondays, or the first day of the school week, and they are held to delegate responsibilities and give reports on the upcoming and past events of the club. The club officers and focus team captains were required to attend and manage these meetings. The main purpose of these meetings was to make an agenda for the next club meeting, receive updates from each focus team, and air any "dirty laundry" we may have. During these meetings this year, we discussed things like events held at our school sponsored by us, for example, the installation of club officers, the awards ceremony, and 8^{th} Grade visitors.

E2. Weekly Club Meetings

The focus of the meetings is based on the activities of the time period. From September through December, most meetings are about the Science Fair with work sessions to help students complete a successful project and periodically presenting their progress and projects to the other members. We had several Mentors from the WPAFB such as: Ed Hurd, Mark Weems, Steven Faris, Bed Roth, 2^{nd} lieutenant Joe Svejkosky, and Captain Jeremy. We also had some other mentors such as the five leading officers and Mr. Don Sanders. If we have any new, conditional members, we have introductions and a few activities that allow us to meet and greet. After science fair, which is around January, we try to focus our club meetings on our focus teams and the activities they have coming up. From the start of the school year until March, our club pays much attention to T-Mal, sponsored by the National Society of Black Engineers Jr. Chapter. Between the months of January and March, our club focuses on Robotics for the rest of the school year, as it gets warmer outside, our club focuses on Flight and Environmental team activities.

Our club meeting usually work like this: the vice president of math begins each meeting with a call to order and informs all members of the agenda. Next, the vice president of math continues on with new business and announcements and has team captains come forth with any reports. Students then move on to the focus of the meeting which can be a keynote speaker, debrief from the president, Engineering of the Month activity, or a fun science lab. Key speakers provide information of math and science and real life applications. In the 2012-2013 school year, we have had a few speakers ranging in various STEM fields. The guest speakers we acquired throughout the school year are Mr. Lawrence, Dr. Lowell, Ms. Seana McNeal and Mr. Mike Zwyien. We also have had a few different activities such as the Little Ball Lab, Mousetrap Car Races, a Programming tutorial and a Wiring tutorial.

On the Wednesdays between August 29, 2012 and September 12, 2012 we focused mostly on working on Science Fair Projects with the mentors we had coming in. Students got into groups of five and worked with a mentor.

On September 19, 2012 Dr. Lowell from Central State University came and brought us a Lab called "The Little Ball". The little ball lab challenged students to be innovative and create

their own lab using certain materials. The students' objective was to find a difference in five balls that wasn't their color. The materials were a graduated cylinder, a balance, water, five foam balls each of a different color, and whatever else they could think to use that was readily available. The students then went on to follow the scientific method. First, students had to identify their problem. The problem was to find a difference between the five different ball outside of color. Next the students had to create a hypothesis on what they thought the difference was using the If, Then, Because format. Then after students had a correctly formatted hypothesis they had to start to develop a list of procedures on how they were going to test their hypothesis. After they had a list of procedures they had to implement the procedures and test their hypothesis. When they finished their testing they had to then develop a conclusion, discussion, and a what they would do next. They also had to set-up a poster board just like their science fair board. The results that all the students came to was that the difference in the five balls was their density. The measured density by filing their graduated cylinder up to fifty milliliters and dropping the ball into the graduated cylinder. They then recorded the displacement in the water and recorded the information. Next they then weighed each ball using the balance and recorded the weight. Finally they calculated the density by dividing the mass by volume and recording their results. The purpose of this lab was to show students how to go about using the Scientific method.

On October 10, 2012 Mr. Lawrence, who was the previous principle at Thurgood Marshall and is now the DPS Chief of Innovation, spoke to the club members about how important it was to enjoy the opportunity that we have being a part of the Math & Science Club on October 10,2012. He also spoke to the fact that the Math & Science Club is a student-run organization and it is the only student-run organization in the building and in the district

On the Wednesdays between January 9, 2013 to February 13, 2013 the club's activities focused more towards preparing for West District Science Fair on February 2, 2013 and robotics whose stop build date was February 19, 2013

On February 20, 2013 student Mitchell Cowan gave a programming tutorial. Mr. Cowan went over the basic of C++ programming. He talked about "for" loops, "while" loops, and "if" statements. He also went over how the FRC 2013 Build Seasons Robot was programmed, how each function was defined by giving it a name and being told was kind of device it was using, whether or not it was a relay, jaguar or solenoid.

On March 6, 2013 student Kadijah Taylor gave a wiring tutorial. Ms. Taylor went over the basic of wiring. She talked about how to strip/cut a wire, some of the basic vocabulary used when wiring, and the importance of some of the devices, such as the digital sidecar, the cRIO, the power distribution board, the kill switch, and the power converter, wired on the FRC 2013 Build Season's Robot.

On April 3, 2013 Students built mousetrap car. On April 10, 2013 the students raced their mousetrap cars. In the mousetrap car races students built cars that ran only by the power of a mousetrap. It was then made in to a competition of who could get the farthest distance and the fastest speed. Students worked in pairs to accomplish this goal. Khayln Miller and Mitchell Cowan won first place which was the farthest distance, and Sade Foster and Tarrick White won second place which was the fastest speed.

Ms. Seana McNeal was the speaker at the Installation and Awards Ceremony on May 15,2013. She was raised in Dayton, Ohio and is an Electrical Engineer in the Electrical Systems Branch of the Aerospace Systems Directorate (AFRL/RQQE) in the Air Force Research Laboratory. As a civilian employee she has been a researcher and program manager in the area

of power management and distribution. Her work focuses on improving the electrical power system in aircraft through component and architecture development. She is a member of several professional organizations including the National Society of Black Engineers Dayton Alumni Extension and the Institute of Electrical and Electronics Engineers' Power Electronics Society.

Mike Zwyien is the program manager for the project "Blue Devils" which is a project where small planes are sent to soldiers and used to prevent soldiers from walking into an area blind. The soldiers send the plane to fly overhead of the area they are about to walk into and the plane gathers the information and sends it to the soldiers so that they are prepared. He spoke on May 22, 2013.

The Math and Science Problems and answers the student completed during the 2012-2013 school year are as follows:

1. The first Set of Problems was:
    a. Write the point slope form of the equation of the straight line having slope "m" and passing through the point (X1, Y1); y-y = m(x,-x)
    b. Write the slope intercept form of the equation of the line having slope "m" and "y-intercept"; y = mx + b
    c. Write the intercept form of the equation of the lines who x intercept is "a" and whose y intercept is "b", where (a) (b) is not equal to zero; x/a + y/b = 1
    d. What is the equation for Newton's second law of physics; F=ma.
2. The Second Set of Problems was:
    a. Construct a line with slope "m" and y-intercept "b" of the following equation: Y= 3/2(x)-2;
    b. Construct a line with "m" and y-intercept "b" of the following equation: Y= -3(x)+5/2.
    c. Determine how much work is done against gravity in lifting a 3kg object through a distance of 40 cm; 11.76 Joules.
3. The Third Set of Problems Was:
    a. A bicycle rider rides 400 meters of a bicycle path in a time of 60 seconds. What is the average speed of the cyclist? Express the answer in terms of a)feet per second and b) miles per hour; a) 23 feet/second b) 16 miles/hour.
    b. Velocity is a vector quantity: write the mathmatical equation for average velocity. 1b. Acceleration measures the time rate of change of velocity. Write the mathmatical equation for average acceleration. Answer to Science Problem(s): 1a = V=d/t, 1b = A=Vf - Vo/t.

The Riddles that the students solved are as followed with their answers:

1. I come once in a minute, twice in a moment, but never in a thousand years.
   Answer: the letter "m"
2. I always run, but never walk. I have a bed, bur don't sleep. I have a mouth, but i don't eat.
   Answer: River
4. When you put this in a heavy wooden box, the box will become lighter.
   Answer: a hole
5. You hear my sound, you feel me when i move, but see me you never will.
   Answer: wind
6. I follow you all day long , but when the night or rain comes, i am all gone.

Answer: shadow

7. The more i dry, the wetter i get.
   Answer: towel
8. I am very heavy, but backwards, im not.
   Answer: ton
9. A cowboy rides into town on Friday. He stays two days, then leaves on saturday. How can this be?
   Answer: the horses name is Friday
10. What five letter word becomes shorter when you add two letters to it?
    Answer: short
11. What can go up a chimney down, but cant go down a chimney up?
    Answer: an umbrella
12. Can you name four days that start with the letter "T"?
    Answer: Tomorrow, Thurday, Tuesday, Today.
13. The maker doesn't want it, the buyer doesn't use it, and the user doesn't see it, what is it?
    Answer: a coffin

E3. Focus Team Activities

E3.1 Robotics Team

The robotics build season began January 5, 2013, with the kickoff and announcement of this year's game from First robotics. The robotics team would meet every day Monday – Friday from 4:00 P.M. – 7:00 P.M, sometimes later, and on weekends. Their task was to build a robot that could play a game called "Ultimate Ascent". The team received help from mentors that came out from Booz-Allen-Hamilton, Wright-Patterson Air Force Base, Isaac Fluid Power, and Brainerd Industries. Throughout the build season, the robotics team captain, Jasmin Sanford and Khayln Miller, would keep the general body of the club updated on the progress of the robot.

E3.2 T-MAL

For the 2012-2013 school year, the Math and Science Club followed up with what was established last year and allowed its students to take part in a Try-Math-a-Lon, also known as T-mal. This program is designed to increase the students' Math SAT and ACT scores by bringing in mentors with STEM backgrounds not only from the Air Force Research Lab, but also form the surrounding universities like Wright State and University of Dayton.

T-mal is also a fun competition! Every other Saturday morning of the month between September-March, the students would gather at Thurgood Marshall High School; ready to be enriched for our standardized tests as well as one of our upcoming competitions. Not only did our club members take home 1st and 2nd place at the local competition, but we also received the chance to compete in the regional competition in Chicago, IL. The T-mal program has also done about for our students' test scores; proving that the program has raised students' Math ACT scores by an average of three points.

On the first T-MAL (August 25,2012) meeting students toke an Aptitude Survey & Assessment Test. On September 8, 2012 each student was first given a folder to bring to each meeting to hold their documents and note, Next students went over questions that were on the Assessment test, they were told to use three steps, 1. Identify the givens, 2. Identify what you need to find, 3. Solve for solution. Lastly Mr. Marcel gave each student a homework assignment.

It was to find an inventor that interested the student and write a 100 word essay typed, doubled spaced, and in point 12 times new roman font.

Over the following weeks students split into groups according to their math classes and reviewed work they were currently working on in class. Pre-Calculus student reviewed the Unit Circle and the different aspects of the unit circle. Pre-Calculus students studied unit circle for a few weeks. Geometry students analyzed perpendicular and parallel lines, then studied point slope intersections. Algebra students studied conversions and functions, then looked at the vocabulary of algebraic functions.

E4. Club Field Trips

Throughout the school year the Math and Science Club went on field trips to places relevant to advancing student interest in the club and STEM applications. These trips included the activities described in the following sections.

E4.1 FIRST Robotics Kickoff

On January 5, 2013 the FRC kickoff was held at Colerain high school in Cincinnati, OH. Captain Jasmin Sanford toke Co-captain Khayln Miller, members Shepria Pointer, Tyrone Berry, Malik Bursey, Raeshawn Early, Tory Sanders, Tarrick White, and Sade Foster, Alumni members Takeisha Hankins and Brittany Davis-Rowe, and Mentors Matt Vryser and Jeremy Warren. From 10:30 am to 11:30 am the students watched the telecast of the FRC 2013 competition kickoff. From 11:30am to 12:00 the students were able to view the partial playing field. From 1:00 pm to 2:30 pm students went to various workshops. The workshops were as follows: Game Rules exploration and Game Strategy Development, Robot Rules Exploration, Kit of Parts Review, Team Timeliness, and LabView. In the Game Rules exploration and Game Strategy Development workshop, students learned the advantages and disadvantages towards playing offense and defense. They also learned the specifics of the rules to play the game. In Robot Rules exploitation workshop, students explored, reviewed, and detailed the robot rules. In the Kit of Parts Review workshop, students inventoried and reviewed the Kit of Parts for Team 144 while being introduced to the items in the Kit of Parts. In the Team Timelines workshop students were to learn how to plan for the six week build period. In the LabView workshop students learned about running programs keys to controlling robot programs. Every student only went to one workshop. Those that went to the Game Rules exploration and Game Strategy Development workshop were Jasmin Sanford, Khayln Miller, Takeisha Hankins, and Brittany Davis Rowe. The student who went to Robot Rules exploitation was Malik Bursey. The students who went to the Kit of Parts Review Workshop were Shepria Pointer, Sade Foster, Tyrone Berry and Tarrick White. The students that went to the LabView workshop were Tory Sanders and Raeshawn Early.

E4.2 FIRST Robotics Queen City Competition

On March 20 – 23, 2013 the FRC Robotics team went to the Queen City Regional Competition in Cincinnati, OH. Captain Khayln Miller toke Co-Captain Jasmin Sanford, Secretary Mitchell Cowan, and members Kadijah Taylor, Shepria Pointer, Sade Foster, Tyrone Berry, Tarrick White, and Malik Bursey. He was also accompanied by, team mentors, Mr. Henry Noble, Ms. Glenda Konechney, Mr. Samuel Eckhart, and Mr. Jeremy Warren, of Booz Allen Hamilton, Mr. Shane Howard, of Isaac Fluid Power, and Mr. Matt Veryser, a Senior FIRST robotics team member.

The goal in this game is to create a robot that can play a game of Frisbee making anywhere from 1,2 or 3 points during the tele-operated period and anywhere from 2,4 or 6 points during the autonomous period. This game also had another catch the teams could choose to get their robot to climb on different levels of a pyramid, each level having a different point value.

At the competition, the team faced several problems. The first problem faced was passing the inspection. The students had to fix a few bumpers because they were not regulated, the students had to rewire the compressor because it was wired incorrectly, and students had to download the latest version of the Driver Station. After these issues were corrected the students passed inspection with a robot that weighed in at 119.7 lbs. the next problem that was faced was dealing with the autonomous mode. The code was having an issue with the switching from the autonomous period in to the teleoperated period. The problem was the "for" loop. The for loop was being ran 9 times so its time limit was pass the 15 sec period of the autonomous mode. This made the code want to finish the "for" loop before moving on. So the students solved the problem by eliminating the "for" loop and manually entering the code for the "for" loop. The following problem is the problem that the team had the biggest issue with. The pneumatic system had an air leak. The students were able to figure out that they had to leaks one in the tubing and one in an actuator. They fixed the leak in the tubing but they found that one of the fittings on the actuator was broken so they had to change the whole actuator. This leak created an even bigger problem for the team considering they need to fill up the air tank for all the components to work in the autonomous period but by the end of the long queuing time all the air had leaked out. Despite all the obstacles the team faced the managed to rank 25 out of 59.

E4.3 NSBE Regional Conference

On November 9 – 11, 2012, the NSBE Region IV Fall Regional Conference was held at the Hyatt Regency O'Hare. NSBE Jr chapter President Kadijah Taylor was accompanied by Vice President Mitchell Cowan, Secretary Jasmin Sanford, and members Tarrick White, Tyrone Berry, Sade Foster, Shepria Pointer, Niesha Blanks, TaVon Booker, Kyle Knight, Mariah Moss, Shelby Whorley, Jasmin Lynch-Like, Malik Bursey, and Khayln Miller. We were also accompanied by sponsor Mr. Henry Noble, Ms. Glenda Konechney, Mr. Marcel Anthony, Mr. Sam Eckhart, and Ms. Diana Outten. First a brief study hall session was held, this is where everyone went over NSBE facts, Algebra and Geometry problems to prepare the team members for the Quiz Bowl that they were supposed to participate in. After lunch the students took a tour of Northwestern University and had an activity where they were able to network with the other PCI members that attended. Unfortunately, due to our low scores on the World Program Assessment test (PAT) and the Technical Engineering Curriculum (TEC) tests the TMAL teams took, they did not participate in the Quiz Bowl. So we attended many workshops and other offered activities, and even attended a talent show where some of our members performed.

We met several important NSBE members such as, one of the Chicago Six's own Anthony Harris. He taught us some tips on becoming successful and also how he became successful, in a workshop. We sat in with Alumni member Delano White, who gave us the opportunity to fill his shoes for a while and answer questions that would lead up to a mocked regional conference. Another important part of our trip was attending the College/Expo Convention. Several of the students purchased some of the available NSBE merchandise and then talked to some colleges and businesses about their success stories and future opportunities. There was also an inspirational speech from Dr. Carl Mack, who spoke at our banquet about how we as a team of NSBE affect the community or should at least.

The overall results of this trip for each student should have been to further gain network skills, gain a background in our African American history and community. Also to learn that we can achieve any goal we set forth without having to become as many would say the borrower.

E4.4 Amazing Race

The amazing race challenged was based after a TV show but the NSBE Jr chapter coordinators made it more about math. Each month the team received a challenge that they had a whole month to complete. The December/January challenge was to answer the quiz bowl questions, which were focused on Algebra, Geometry, Problem Solving, Numbers and Operation, Data Analysis, and Black History facts. The students had to show all work and an another fact about the black history. The students then had to create a video showing them giving back to the community. The January challenge was to create 20 SAT problems with answers and a one page portfolio of the team complete with a team photo. The SAT problems were graded on difficulties and originality. The February/March challenge was write a one page paper on a famous black inventor or scientist from the state they lived in and to create a mousetrap car that they then recorded the longest distance traveled. Our Club's Amazing Race submissions are attached, along with the powerpoints the held the problems students had to solve during the first challenge.

E5. Science Fair Cycle and Awards

Every year, any student who wishes to be in our club must participate in the school science fair. At the school science fair, we had a great number of participants. And the Dayton District Science Fair, we had the largest number of students from any high school there and also conquered awards from every category. For the West District Science Fair, our club took about 10 students and the awards that our school took home are listed below.

E5.1 Research Projects:

Below are the results of Thurgood Marshall's Building Science Fair.

- Kadijah Taylor (Superior Rating and 1st place in the Junior class)
- Khayln Miller (Superior Rating,)
- Mitchell Cowan
- Sade Foster
- Jasmin Sanford
- Malik Bursey
- Tarrick White
- Tyrone Berry
- Shepria Pointer

Below are the results from the District Science Fair

- Kadijah Taylor (Superior Rating, 1st place in Division, 1st Place in Materials and Manufacturing Category)
- Khayln Miller (Superior Rating, 3rd place in division, 2nd place in Materials and Manufacturing Category)
- Mitchell Cowan
- Sade Foster
- Jasmin Sanford

- Malik Bursey
- Tyrone Berry
- Shepria Pointer

Below you will find all of the research projects that placed and won awards at the regional level. This year, we also had four projects receive Superior ratings and moved on to the State Science Fair competition. These were Khayln Miller, Grade 10, Sade Foster, Grade 10, Mitchell Cowan, Grade 11, and Kadijah Taylor, Grade 11.

- 4 Superior Projects qualify for State Science Day and 12 Special Awards
    - ISA $100 Cash Award and Certificate – Kadijah Taylor Grade 11
    - CSU Manufacturing Engineering Department – Boeing Scholarships of $3000 per year (renewable 3 more years for total of $12,000) Jasmin Sanford, Kadijah Taylor Grade 11
    - United States Air Force Certificate of Achievement Award – Jasmin Sanford, Kadijah Taylor Grade 11, and Khayln Miller Grade 10

Next you will find the abstracts of all Club Members. State participants will be stated. Each abstract will be headed with students name, grade, and the title of their project.

E5.1.1 Jasmin Sanford, Grade 11, Belt Performance in FIRST Robotics

The engineering question for this project is "Which size rubber synchronous belt will provide more efficient performance by the elasticity?" The hypothesis was "If weight is applied to three 5mm synchronous belts that has different values of teeth to test the tolerance, then the belt with a median amount of teeth will have the greatest tolerance strength because by the belts having different amounts of teeth it allows them to come in contact with the gears more frequently and easier creating less slippage." Independent variables discovered in this project were; models of synchronous belts and weight. Dependent variables would be force, length change, and widths of each belt in relevance to pitch. This will be tested by building a rig that will act as a single pulley system holding an amount of weight to find the force being exerted. This will be recorded by the Lab Quest monitor and Duel Range Force Sensor. In this project the belts have stretched at a slow rate but enough to find an average. The hypothesis was proven correct, although each belt did change its shape during the test, the 5MR1500 rubber synchronous belt held the most force with the least amount of change in length.

E5.1.2 Kadijah Taylor, Grade 11, Robotic Arm Controls (State Participant)

The engineering goals of this project were 1) to create a different mode of communication and control for a robotic arm that came out a kit, see if it works, and to measure if the new mode of control bettered the device 2) to improve the modified design by implementing H-Bridge drivers to control the direction the motors move electronically, and 3) to be able to make the arm pick up a small object. These goals are important because they are for the improvement of a hobby level arm. This project successfully demonstrates that the wired controller of an inexpensive hobby level robotic arm can be replaced by an Arduino microcontroller. The materials were the Arduino Uno, Transistor, Relay, Breadboard, Wires, Wire cutters/wire strippers, OWI Robotic Arm Edge Kit, 3 Quadruple Half-H Driver, Arduino Software, and Arduino code. First a hobby level robotic arm was taken apart and examined in order to learn how to control it. Next the robotic arm was wired to a transistor-relay circuit. Then the circuit was connected to the Arduino Uno and was programmed by a computer through a USB cable.

A small program was ran to prove control over robot. The project proved that the Robotic arm could be controlled with the arduino Uno. Next the arm was wired to three half-h drivers, and was programmed to move on its own in both the forward and backwards directions. The final stage was to be able to make the robotic arm pick up an object.

E5.1.3 Khayln Miller, Grade 10, Which has More Lift? (State Participant)

The purpose of this experiment was to find out which wing shape would produce the most lift between rectangular, elliptical, delta, and swept back wings. My hypothesis is if I test them in a wind tunnel at three different angles, then record how much lift each produces at each angle, I think the elliptical wings will produce the most lift for each angle because this design reduces drag and create lift faster than other airfoils because of its unique design.

My procedure was as follows: First I placed the first airfoil in the wind tunnel at a 5 degree angle. Next I turned on the wind tunnel at half speed. After that I recorded how much lift is produced. Next I switched the wind tunnel to full speed and recorded how much lift is produced. Then I changed the angle of attack to 15 degrees and 25 degrees and repeat steps 2-5. Finally I repeated steps 1-6 for the other three airfoils.

My hypothesis was disproven. The elliptical shaped wing had the best lift at 15 degrees, but it didn't have the greatest lift for the other 2 angles of attack, the rectangular shape wing did. I believe the difference of area and design between the elliptical shaped wing and the other wing shapes caused my hypothesis to be wrong.

E5.1.4 Malik Bursey, Grade 10, Eggcelent Heat Transfer

We all eat and many of use cook, but a problem many of use cooks face is finding the right temperature to cook foods at. In this project I'm going to be investigating just that by cooking eggs. The purpose of this project is to find the lowest temperature, or amount of heat, is needed to fully cook a 3 egg omelet, over an oven burner, in a non-stick pan, in under 20 minutes. I do this in three trails, each set at different temperatures of 200*F, 300*F, and 400*F. For each trail I follow the same process of cooking the only changes are temperature, and time in takes omelets to cook, if at all, within the 20 minutes time period. I hypothesized that the egg omelet would fully cook in under 20 minutes at a temperature of 200*F I quickly found that I was wrong. Of the three trails, the only one not able to fully cook the omelet was the 200*F trail. This data, along with others findings, can greatly aid that of cooks because it can led to knowing the perfect temperature to cook any food, including egg, which would put many cooks, myself included, at greater ease.

E5.1.5 Mitchell Cowan, Grade 11, Neutralization Titration, (State Participant)

With the increased production of sulfuric acid in the United States, there’s an increase usage level of sulfuric acid in the industrial area and in the chemistry field, but this is a strong dangerous acid. With a higher production and usage level of this chemical, there’s a greater chance of accidental chemical spills or leaks that can affect the environment and people around it. To save the environment, we need to find a way to neutralized sulfuric acid using bases such as sodium hydroxide and calcium hydroxide which are strong bases, magnesium hydroxide, and ammonium nitrate which are weak bases. The question is which base can neutralize sulfuric acid completely using the least amount of base? My hypothesis says that if sodium hydroxide is added to sulfuric acid, then the sulfuric acid will be neutralized using the least amount base because of the strength of sodium hydroxide and it’s concentration.

The sulfuric acid was the independent and at a set concentration. The bases of sodium hydroxide, calcium hydroxide, magnesium hydroxide, and ammonium nitrate were tested in three trials at different concentration ratios of 1:1, 1:10 and 1:100. The process used to test these acid base reactions was a process known as neutralization titration, and the indicator used for visible neutralization endpoint was phenolphthalein.

During titration there was no visible reaction between the sulfuric acid and the bases, as a result there were no bases that completely neutralized the sulfuric acid, and the hypothesis was disproven.

E5.1.6 Sade Foster, Grade 10, Fruity Carbs (State Participant)

The purpose of this project is to find out which fruit juice has the most carbohydrates in it? My hypothesis is <u>if</u> I put 4mL of a fruit juice and 1mL of iodine solution <u>then</u> I will be able to determine that white grape juice will turn the darkest color <u>because</u> it has the highest carbohydrates. My methods are first Put on safety goggles, second make boiling water on the strove third put 4mL of a fruit juice in a test tube forth add 1mL of iodine solution to the test tube, fifth stir it well sixth put the test tubes in the water seventh wait several of min. or wait till the color change, lastly record my results and do the same for all fruit juice. My results were the orange juice had the lowest carbohydrates. It's changed to the color orange which mean its low. The apple juice had the high carbohydrates. It's changed to brown. But then I did it again and the white grape and apple juice had the same color which was brown. So they both were high. My conclusion is the hypothesis that I had was wrong when I test it the first time. But then I tested it again it was almost right the only thing it was it was a tie between the two. My hypothesis was right but you don't get the same results. So you have to test it over. It was very subjective. Which mean it was visible check.

E5.1.7 Shepria Pointer, Grade 11, What's Bringing the Most Heat?

My project is called What's Bringing The Most Heat. The purpose of my project is to see which transfers heat the best at a faster rate between conduction, convection, and radiation. My hypothesis was that if I get a boneless chicken breast and place it on a metal pan in a conventional oven, then get another chicken breast and place it on an aluminum pan in a convection oven, and also get another chicken breast and place it in a plastic container and put it in the microwave, then I think that the chicken breast using convection will transfer more heat at a faster pace because in the convection oven all heat is the same temperature throughout the convection oven. The chicken would be getting cooked the same amount all around. I used three 4 oz. chicken breasts, a metal pan, an aluminum pan, and a plastic container. I for each chicken breast I used them for conduction, convection and radiation. I put the different chicken on the metal pan, aluminum pan, and in the plastic container for 2 minutes, 4 minutes, and 8 minutes. After 8 minutes, the chicken breast using conduction was the only one that didn't cook thoroughly. My hypothesis was correct. The chicken breast using radiation did cook at a faster pace and more thoroughly.

E5.1.8 Tarrick White, Grade 9, How Efficient is a Solar Panel

The purpose of me doing this project is to see how a solar panel could change our daily lives. People should care about this project because it could be a step forward to making a car completely electronic. Seventy five percent of air pollution is from cars and my project shows a way that we can cut back on air pollution. My hypothesis was that if I use a 10 volt solar panel I

would get to drive my RC car longer than without it. The results obtained from this experiment prove my hypothesis was correct.

E5.1.9 Tyrone Berry, Grade 9, Which Fruits and Vegetables Make the Best Battery

The purpose of my project is to tell which fruit will make the best battery. My procedure is first I have to plug the galvanometer into the fruits and look at the galvanometer to see the number in order which is strongest. And then I have to test the other fruits to see which one is the strongest again and then I have to test those 3 more times for good evidence. Finally my conclusion is my results is that what I found out is that my hypothesis was wrong because I guessed that the lemon would be the most acidic but I was wrong it was the grapefruit that was the most acidic and the way I got my results was that the galvanometer was hooked up into the fruits and I looked at the galvanometer and it said grapefruits was the most acidic or the would have the best battery.

E5.2 Installation and Award Ceremony

The Installation and Awards Banquet was held on 15 May 2013 at 4:00pm in Thurgood Marshall Auditoria. The club officers for the 2013-2014 school year were installed. Kadijah Taylor was installed as the new President, Mitchell Cowan was installed as the new Vice President of Science, Shepria Pointer was installed as the new Vice President of Math, Sade Foster was installed as the new Secretary of Science and Khayln Miller was installed as the new Secretary of Math. Each officer had to say their oath that reflected their responsibilities in the charter. After installation the Awards Ceremony was held. The awards were for the club members' achievements throughout the year. Ms. Seana McNeal was our speaker and spoke to the members about the three tiers to success. The three tiers were first decide where you are going, plan how you will achieve your goal, and then execute your plan. She then went on to talk about how the three tiers applied to her and how she used the three tier to achieve her goals. She also explained some of the obstacles she faced and overcame. After Ms. Seana Finished speaking she was given a small token of appreciation. The token of appreciation was a small cougar statue with an engraved plaque that read "Thurgood Marshall Math & Science Club Mentor" The first set of awards was for the robotics team. Khayln Miller and Jasmin Sanford were awarded a mug for their leadership of the robotic team and a metal and game logo pin. The other members, Kadijah Taylor, Sade foster, Tarrick White, Tyrone berry, Malik Bursey, Mitchell Cowan, Shepria Pointer, Tory Sanders, and Raeshawn Early were awarded a metal and game logo pin for their participation. The next group of awards was for outgoing officers. Khayln Miller received a stationary pin set for his role as secretary of science, Shepria Pointer received a stationary pin set for her role as secretary of math, Jasmin Sanford received a gavel set for her role as Vice President of Science, Kadijah Taylor received a gavel set for her role as Vice President of Math and Mitchell Cowan received a gavel set for his role as Vice President of Outreach. The next group of awards was the NSBE awards. Each student received a certificate of achievement and a medal for participation in the Amazing Race Challenge. Those students were Kadijah Taylor, Mitchell Cowan, Jasmin Sanford, Tarrick White, Tyrone Berry, Sade Foster, Khayln Miller, Shepria Pointer, and Malik Bursey. The next award was for the mentors of the club. They received a pocket tools set that read Thurgood Marshall Math & Science Club Mentor. The mentors were Donnie Saunders, Joe Svejkosky, Ms. Sharon Goins, Dr. Lightfoot, Mr. Temmesfeld, Mr. Hank Baust, Dr. Eric Jones, Mr. Marcel Anthony, Ms. Seana McNeal, and Ms. Brittany Davis-Rowe. The next group of awards was for the state science fair participants. Each participant received an Air force medal. They were Kadijah Taylor, Sade Foster, Mitchell

Cowan, and Khayln Miller. Next the awards for those student who received a summer internship were handed out. They received a certificate of achievement. Those student were Kadijah Taylor, who will be working for SAIC, Mitchell Cowan, who will be working for SAIC, Shepria Pointer, who will be working for SAIC and Khayln Miller, who will be working at the Air Force Aerospace directorate. Next a special award was given to Mr. Henry Noble and Ms. Glenda Konechney from the student and as a special thank you. The last group of awards was called the Special Awards giving to student for exceptional achievements. Mr. Tyrone Berry received an award for an outstanding performance as a freshman, Mr. Malik Bursey received an Awards for having the exceptional talent for specific details, Mr. Tarrick White received an awards for taking initiative and going the extra mile, Ms. Kadijah Taylor received an award for being an exceptional leader and going beyond requirements, and Mr. Khayln Miller Received an award for receiving a perfect score at state science fair.

E5.3 Club Charter Modifications:

The Math and Science Club made some changes to their charter in order to make the club run more smoothly. The charter is similar to the constitution in that it is a living document, changes were made on subjects that were not specified or mention that sometimes made running the club harder. The following changes to the Math and Science Club Charter:

- Changing the year from 2012 – 2013 to 2013-2014
- The Vice President of Outreach position will be removed.
- The Secretary of outreach position will be removed.
- The Vice president of math will be the co-captain of robotic.
- The secretary of science will be the secretary of robotics.
- The secretary of math will be the secretary of NSBE

APPENDIX F
Research Projects Academic Year 2012-2013

F1. Robotic Arm Controls, Kadijah Taylor, Grade 11

F1.1 Abstract

The engineering goals of this project were 1) to create a different mode of communication and control for a robotic arm and see if it improves the device 2) to improve the modified design by implementing H-Bridge driver to control the direction the motors move electronically, and 3) to be able to make the arm pick up a small object. This project successfully demonstrates that the wired controller of an inexpensive hobby level robotic arm can be replaced by an Arduino microcontroller. The materials used were Arduino Uno by Sparkfun Electronics, Transistor, Relay, Breadboard, Wires, Wire cutters/wire strippers, OWI Robotic Arm Edge Kit, 3 Quadruple Half-H Driver, Arduino Software, and Arduino code. First a hobby level robotic arm was taken apart and examined in order to learn how to control it. Next the robotic arm was wired to a transistor-relay circuit. Then the circuit was connected to the Arduino Uno, which is a programmable micro-controller, programmed by a computer through a USB cable. A small program was run to prove control over robot. The project proved that the movements were less jerky with the arduino sensor. Next the arm is wired to three quadruple half-h drivers, which is a h-bride that can control two motors and can control the flow of current in both directions, and programmed to move on its own in both the forward and backwards directions. The final stage was to be able to make the robotic arm pick up an object.

F1.2 Introduction

In this project the original mode of control for a hobby level robotic arm was removed and a different way of controlling it was utilized. The goal was to see if there was a way to make the robotic arm well-rounded, where you could change the speed. So if the operating platform is changed then the efficiency of movement will be better and allow the users more control over the device. By using this design a wide range of possibilities are now made available like controlling the device wirelessly.

F1.2.1Engineering Goals:

- To create a different mode of communication and control for a robotic arm that came out a kit, and see if it betters the device.
- To better the modified design by implementing H-Bridge driver to control the direction the motors move electronically.
- To make the arm pick up a small object.
- To make a mobile application to control the robotic arm.

F1.3 Background

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins and an operating voltage of 5 volts. The Arduino Uno can be powered by the USB connection or with an external power supply. External power can come either from an AC-to-DC adapter or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the power connector. Vin is the input voltage to the Arduino board when it's using an external power source. You can supply voltage through this pin or, if supplying voltage through

the power jack, access it through this pin. Gnd is the ground pins. When the term “ground” is used when talking electricity it means the negative terminal.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistance of 20-50 kOhms.

The transistor is a three terminal, solid state electronic device. In a three terminal device we can control electric current or voltage between two of the terminals by applying an electric current or voltage to the third terminal. This three terminal character of the transistor is what allows us to make an amplifier for electrical signals, like the one in our radio. With the three-terminal transistor we can also make an electric switch, which can be controlled by another electrical switch. By cascading these switches we can build up very complicated logic circuits. These logic circuits can be built very compact on a silicon chip with 1,000,000 transistors per square centimeter. We can turn them on and off very rapidly by switching every 0.000000001 seconds. Such logic chips are at the heart of your personal computer and many other gadgets we use today. It has three parts, the base, the collector, and the emitter. The base is the gate controller device for the larger electrical supply, the collector is the larger electrical supply, and the emitter is the outlet for the larger electrical supply.

In 1947, John Bardeen and Walter Brattain, working at Bell Telephone Laboratories, were trying to understand the nature of the electrons at the interface between a metal and a semiconductor. They realized that by making two point contacts very close to one another, they could make a three terminal device - the first "point contact" transistor. They quickly made a few of these transistors and connected them with some other components to make an audio amplifier. This audio amplifier was shown to chief executives at Bell Telephone Company, who were very impressed that it didn't need time to "warm up". They immediately realized the power of this new technology. This invention was the spark that ignited a huge research effort in solid state electronics. Bardeen and Brattain received the Nobel Prize in Physics, 1956, together with William Shockley, "for their researches on semiconductors and their discovery of the transistor effect." Shockley had developed a so-called junction transistor, which was built on thin slices of different types of semiconductor material pressed together. The junction transistor was easier to understand theoretically, and could be manufactured more reliably. The junction transistor is only one of the two types of transistors, the other one is the field effect. Field effect transistors have only two layers of semiconductor material, one on top of the other.

Relays are a simple electromechanical switch made up of an electromagnet and a set of contacts. An electrical relay is a switch which is under the control of another circuit. The earliest electrical relays were developed in the 1830s, as people began to recognize that such switches could be extremely useful. Electrical relays were often made with electromagnets, although for some applications solid state relays are preferred. They key difference between electromagnetic and solid state options is that electromagnetic relays have moving parts, and solid state relays do not. Electromagnets also conserve more energy than their solid state counterparts do. One of the reasons an electrical relay is such a popular tool for electricians and engineers is that it can control electrical output which is higher than the electrical input it receives. Using a relay relatively lightweight wiring can be used, saving space in the circuit. Relays often use the term

normally closed (NC). Normally closed mean that during normal operation this action is left closed.

Diodes are an electrical device allowing current to move through it in one direction with far greater ease than in the other. When the polarity of the battery is such that electrons are allowed to flow through the diode, the diode is said to be forward-biased. Conversely, when the battery is “backward” and the diode blocks current, the diode is said to be reverse-biased. A diode may be thought of as like a switch: “closed” when forward-biased and “open” when reverse-biased. Oddly enough, the direction of the diode symbol's “arrowhead” points against the direction of electron flow. This is because the diode symbol was invented by engineers, who predominantly use conventional flow notation in their schematics, showing current as a flow of charge from the positive (+) side of the voltage source to the negative (-). This convention holds true for all semiconductor symbols possessing “arrowheads:” the arrow points in the permitted direction of conventional flow, and against the permitted direction of electron flow.

Diode behavior is analogous to the behavior of a hydraulic device called a check valve. A check valve allows fluid flow through it in only one direction. Some diodes are called flyback diodes because they suppress flyback voltage when the transistor is switched off. The flyback diode is used to protect the Arduino pins from unwanted current created by devices with magnets such as motors and the speaker. A diode only lets current flow in one direction. When the device with the magnet becomes unpowered a small amount of current is quickly created which can damage pins when it flows backwards. The flyback diode removes this possibility.

A potentiometer is a three-terminal resistor with a sliding contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat. A potentiometer measuring instrument is a voltage divider used for measuring electric potential (voltage). Potentiometers are commonly used to control electrical devices such as volume controls on audio equipment. Potentiometers operated by a mechanism can be used as position transducers. Potentiometers are rarely used to directly control significant power (more than a watt), since the power dissipated in the potentiometer would be comparable to the power in the controlled load.

Pulse width modulation (PWM) is a powerful technique for controlling analog circuits with a microprocessor's digital outputs. PWM is employed in a wide variety of applications, ranging from measurement and communications to power control and conversion. An analog signal has a continuously varying value, with infinite resolution in both time and magnitude. A nine-volt battery is an example of an analog device, in that its output voltage is not precisely 9V, changes over time, and can take any real-numbered value. Similarly, the amount of current drawn from a battery is not limited to a finite set of possible values. Analog signals are distinguishable from digital signals because the latter always take values only from a finite set of predetermined possibilities, such as the set {0V, 5V}. By controlling analog circuits digitally, system costs and power consumption can be drastically reduced. Many microcontrollers and DSPs already include on-chip PWM controllers, making implementation easy. PWM is a way of digitally encoding analog signal levels. Through the use of high-resolution counters, the duty cycle of a square wave is modulated to encode a specific analog signal level. The PWM signal is still digital because, at any given instant of time, the full DC supply is either fully on or fully off. The voltage or current source is supplied to the analog load by means of a repeating series of on and off pulses. The on-time is the time during which the DC supply is applied to the load, and the off-time is the period during which that supply is switched off. Given a sufficient bandwidth, any analog value can be encoded with PWM.

A finite-state machine (FSM) or simply a state machine, is a mathematical model of computation used to design both computer programs and sequential logic circuits. It is conceived as an abstract machine that can be in one of a finite number of states. The machine is in only one state at a time. The state it is in at any given time is called the current state. It can change from one state to another when initiated by a triggering event or condition, this is called a transition. A particular FSM is defined by a list of its states, and the triggering condition for each transition. The behavior of state machines can be observed in many devices in modern society which perform a predetermined sequence of actions depending on a sequence of events with which they are presented. Simple examples are vending machines which dispense products when the proper combination of coins are deposited, elevators which drop riders off at upper floors before going down, traffic lights which change sequence when cars are waiting, and combination locks which require the input of combination numbers in the proper order. Finite-state machines can model a large number of problems, among which are electronic design automation, communication protocol design, language parsing and other engineering applications. In biology and artificial intelligence research, state machines or hierarchies of state machines have been used to describe neurological systems and in linguistics—to describe the grammars of natural languages.

A decoupling capacitor is a capacitor used to decouple one part of an electrical network (circuit) from another. Noise caused by other circuit elements is shunted through the capacitor, reducing the effect they have on the rest of the circuit. Decoupling is the abstract concept of coupling between two phenomena applies to so many different contexts that the cessation of coupling, or the absence of coupling between two phenomena where it would usually be expected, produces many circumstances where decoupling is a phenomenon of interest in itself. If the voltage level for a device is fixed, changing power demands are manifested as changing current demand. The power supply must accommodate these variations in current draw with as little change as possible in the power supply voltage. When the current draw in a device changes, the power supply cannot respond to that change instantaneously. As a consequence, the voltage at the device changes for a brief period before the power supply responds. The voltage regulator adjusts the amount of current it is supplying to keep the output voltage constant but can only effectively maintain the output voltage for events at frequencies from DC to a few hundred kHz, depending on the regulator (some are effective at regulating in the low MHz). For transient events that occur at frequencies above this range, there is a time lag before the voltage regulator responds to the new current demand level.

An H-Bride is an arrangement of transistors that allows full control over a standard DC motor. The H-Bridge can electronically command the motor forward, reverse, brake, and coast.

F1.4 Technical Discussion

a. Robotic Arm
   a. The robotic arm uses several motors that turn gears which then control the robot. Inside a gear box on the robotic arm is four gears that have a gear on top and bottom so actually it's about eight gears totally. Now a smaller gear is under a larger gear . Then the smaller gear on bottom is connected to a larger gear that's on top. Whenever two gears are on the same axle they move at the same speed, but when that speed is on a small gear that's turning a larger gear the speed decreases. So the initial speed of the motor is decreased by the many gear ratios. A gear ratio is a speed ratio for a gear train.

$$Gr = N_{out}/N_{in} = D_{out}/D_{in} = W_{in}/W_{out} = T_{out}/T_{in}$$

Gr stands for gear ratio. Above listed is the four ratios. Each ratio will be equal to any other ratio. N is the number of teeth, D is the diameter, W is the angular velocity, and T is the torque. The subscripts out and in stand for output and input. The input is from th driving gear and output id the driven gear. In the gearboxes on the robot the driving gear is the one that directly touches the motor and the driven gear are all the ones connected to the one driving.

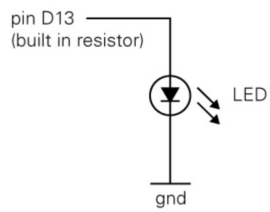
b. Electronics
    a. Though out this project several circuits were made to understand how to control the robotic arm. The first circuit that was created was created to understand how to use the arduino sensor. The circuits purpose was to turn on an LED. The next circuit that was created was created to prove if a motor could be controlled with the arduino sensor. The following circuit helped me understand how a transistor works but it was discovered that the transistor wouldnt be able to control the robot on its on, so a relay was then added. The transistor is with the relay for extra protection so that neither the transistor or relay is burned out. Also the transistor is used as a switch for the relay. In the same circuit a flyback diode is used so that the transistor is not damaged. When the transistor flips on the relay turns on and allows current to flow through the circuit, but when the transistor flips off the relay also flips off and current is stuck in between the relay and transistor and could burn out the transistor. The flyback diode gives the current flow an exscape route so it doesnt damage the diode. The quadruple half h bridge is used to control the motor direction. I use

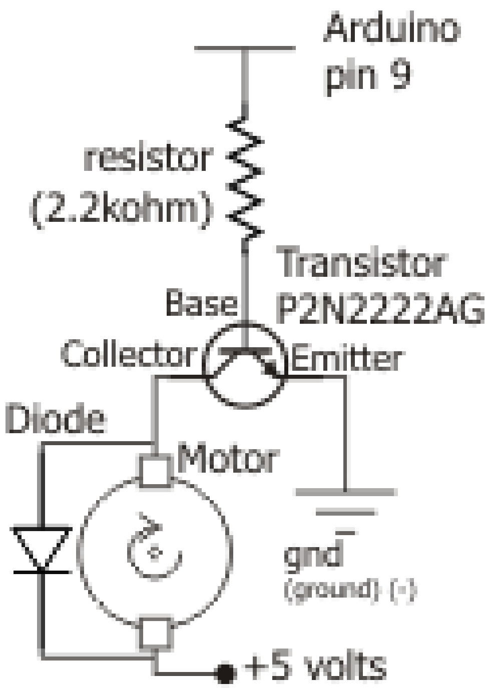
c. Arduino
    a. The arduino sensor is a programmable microcontroller. This is used to adjust the speed of the movements of the robotic arm. This also opens the project to more future possibilities as in being able to control the robotic arm wirelessly.

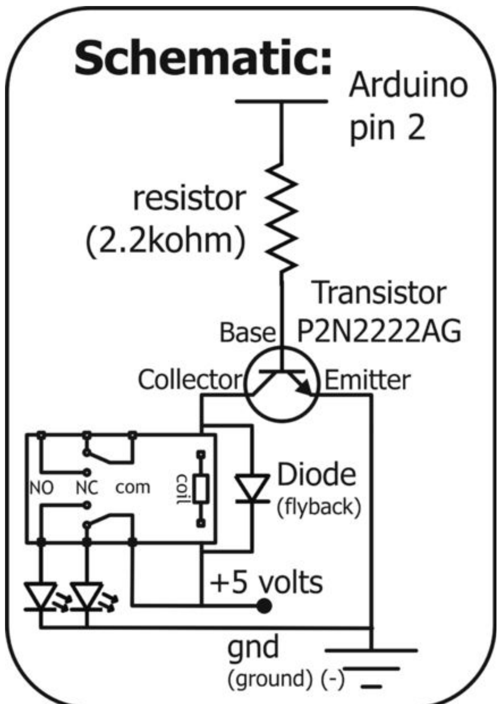
F1.5 Materials

- Arduino Uno
- Transistor
- Relay
- Breadboard
- Wires
- Wire cutters/wire strippers
- OWI Robotic Arm Edge Kit
- 3 Quadruple Half-H Driver
- Arduino Software
- Arduino code

F1.6 Results







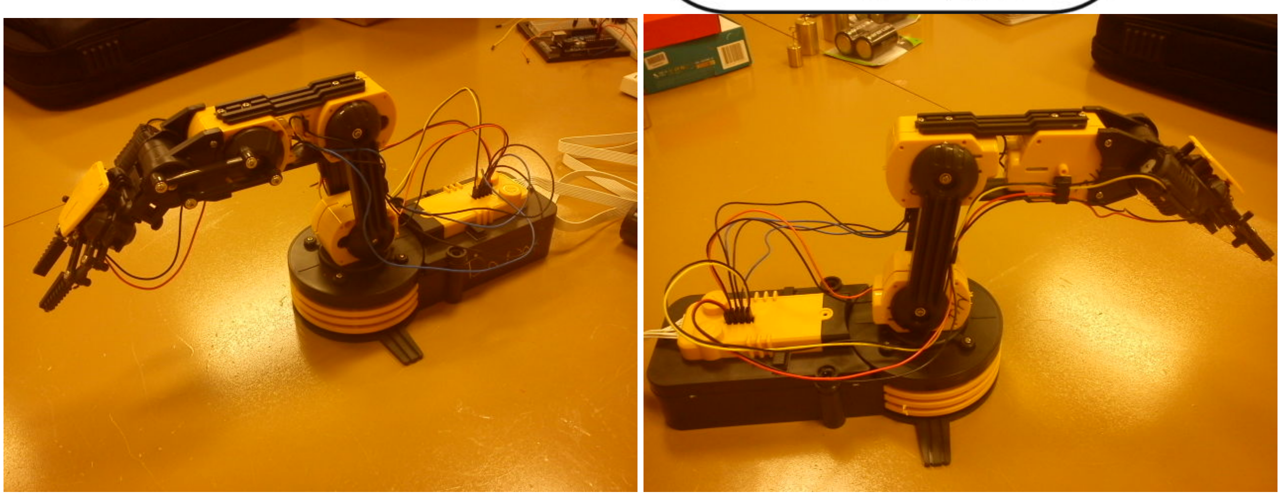


Figure F-1 Before Modification

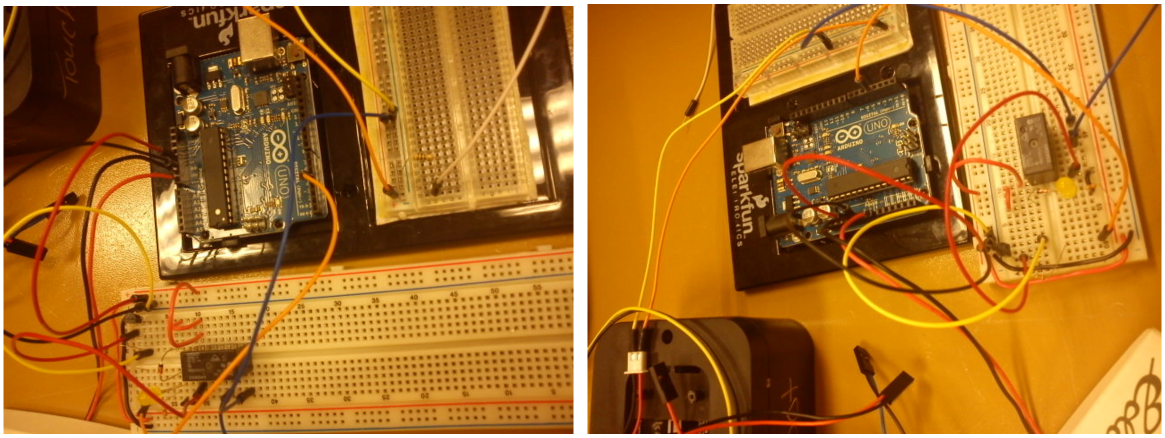


Figure F-2 After Modification

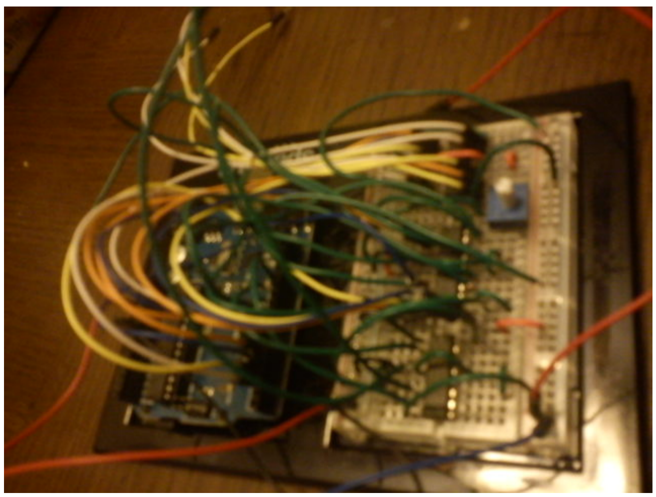


Figure F-3 With H-Bridges

F1.7 Programming Code

```
const int enablePin = 3;
const int motor1Fwd = 2;
const int motor1Rev = 4;
const int motor2Fwd = 5;
const int motor2Rev = 6;
const int motor3Fwd = 7;
const int motor3Rev = 8;
const int motor4Fwd = 9;
const int motor4Rev = 10;
const int motor5Fwd = 11;
const int motor5Rev = 12;

const int speed_slow = 150;
const int speed_med = 200;
const int speed_fast = 255;
```

```
void setup() {
  pinMode(enablePin, OUTPUT);
  pinMode(motor1Fwd, OUTPUT);
  pinMode(motor1Rev, OUTPUT);
  pinMode(motor2Fwd, OUTPUT);
  pinMode(motor2Rev, OUTPUT);
  pinMode(motor3Fwd, OUTPUT);
  pinMode(motor3Rev, OUTPUT);
  pinMode(motor4Fwd, OUTPUT);
  pinMode(motor4Rev, OUTPUT);
  pinMode(motor5Fwd, OUTPUT);
  pinMode(motor5Rev, OUTPUT);

  analogWrite(enablePin, speed_fast);

}

void loop() {
  digitalWrite(motor5Rev, LOW);
  digitalWrite(motor1Fwd, HIGH);
  delay(500);
  digitalWrite(motor1Fwd, LOW);
  digitalWrite(motor1Rev, HIGH);
  delay(500);
  digitalWrite(motor1Rev, LOW);
  digitalWrite(motor2Fwd, HIGH);
  delay(500);
  digitalWrite(motor2Fwd, LOW);
  digitalWrite(motor2Rev, HIGH);
  delay(500);
  digitalWrite(motor2Rev, LOW);
  digitalWrite(motor3Fwd, HIGH);
  delay(500);
  digitalWrite(motor3Fwd, LOW);
  digitalWrite(motor3Rev, HIGH);
  delay(500);
  digitalWrite(motor3Rev, LOW);
  digitalWrite(motor4Fwd, HIGH);
  delay(500);
  digitalWrite(motor4Fwd, LOW);
  digitalWrite(motor4Rev, HIGH);
  delay(500);
  digitalWrite(motor4Rev, LOW);
  digitalWrite(motor5Fwd, HIGH);
  delay(500);
```

```
  digitalWrite(motor5Fwd, LOW);
  digitalWrite(motor5Rev, HIGH);
  delay(500);
  digitalWrite(motor5Rev, LOW);
}
```

F1.8 The Arduino Code used to test all motors.

```
const int enablePin = 3;
const int motor1Fwd = 2;
const int motor1Rev = 4;
const int motor2Fwd = 5;
const int motor2Rev = 6;
const int motor3Fwd = 7;
const int motor3Rev = 8;
const int motor4Fwd = 9;
const int motor4Rev = 10;
const int motor5Fwd = 11;
const int motor5Rev = 12;

const int speed_slow = 150;
const int speed_med = 200;
const int speed_fast = 255;

void setup() {
  pinMode(enablePin, OUTPUT);
  pinMode(motor1Fwd, OUTPUT);
  pinMode(motor1Rev, OUTPUT);
  pinMode(motor2Fwd, OUTPUT);
  pinMode(motor2Rev, OUTPUT);
  pinMode(motor3Fwd, OUTPUT);
  pinMode(motor3Rev, OUTPUT);
  pinMode(motor4Fwd, OUTPUT);
  pinMode(motor4Rev, OUTPUT);
  pinMode(motor5Fwd, OUTPUT);
  pinMode(motor5Rev, OUTPUT);

  analogWrite(enablePin, speed_fast);

}

void loop() {
  digitalWrite(motor3Fwd, HIGH);
  delay(1000);
  digitalWrite(motor3Fwd, LOW);
  digitalWrite(motor3Rev, HIGH);
  delay(1000);
  digitalWrite(motor3Rev, LOW);
```

```
  digitalWrite(motor5Fwd, HIGH);
  delay(1000);
  digitalWrite(motor5Fwd, LOW);
  digitalWrite(motor3Fwd, HIGH);
  delay(1000);
  digitalWrite(motor3Fwd, LOW);
  digitalWrite(motor3Rev, HIGH);
  delay(1000);
  digitalWrite(motor3Rev, LOW);
  digitalWrite(motor5Fwd, HIGH);
  delay(1000);
  digitalWrite(motor5Fwd, LOW);
}
```

Trial 1 for testing pick up.

```
const int enablePin = 3;
const int motor1Fwd = 2;
const int motor1Rev = 4;
const int motor2Fwd = 5;
const int motor2Rev = 6;
const int motor3Fwd = 7;
const int motor3Rev = 8;
const int motor4Fwd = 9;
const int motor4Rev = 10;
const int motor5Fwd = 11;
const int motor5Rev = 12;

const int speed_slow = 150;
const int speed_med = 200;
const int speed_fast = 255;

void setup() {
  pinMode(enablePin, OUTPUT);
  pinMode(motor1Fwd, OUTPUT);
  pinMode(motor1Rev, OUTPUT);
  pinMode(motor2Fwd, OUTPUT);
  pinMode(motor2Rev, OUTPUT);
  pinMode(motor3Fwd, OUTPUT);
  pinMode(motor3Rev, OUTPUT);
  pinMode(motor4Fwd, OUTPUT);
  pinMode(motor4Rev, OUTPUT);
  pinMode(motor5Fwd, OUTPUT);
  pinMode(motor5Rev, OUTPUT);

  analogWrite(enablePin, speed_fast);
```

```
}

void loop() {
  digitalWrite(motor3Fwd, HIGH);
  delay(1000);
  digitalWrite(motor3Fwd, LOW);
  digitalWrite(motor1Fwd, HIGH);
  delay(500);
  digitalWrite(motor1Fwd, LOW);
  digitalWrite(motor3Rev, HIGH);
  delay(1000);
  digitalWrite(motor3Rev, LOW);
  digitalWrite(motor5Fwd, HIGH);
  delay(1000);
  digitalWrite(motor5Fwd, LOW);
  digitalWrite(motor3Fwd, HIGH);
  delay(1000);
  digitalWrite(motor3Fwd, LOW);
  digitalWrite(motor1Fwd, HIGH);
  delay(500);
  digitalWrite(motor1Fwd, LOW);
  digitalWrite(motor3Rev, HIGH);
  delay(1000);
  digitalWrite(motor3Rev, LOW);
  digitalWrite(motor5Fwd, HIGH);
  delay(1000);
  digitalWrite(motor5Fwd, LOW);
}
```

Trial 2 for pickup.

F1.9 Conclusion

The purpose of this project was to create a different mode of controlling a hobby level robotic arm. The reason for tackling this challenge was to create a project that implemented in other daily applications. The result of this project was that the Arduino Uno microcontroller allows the user to adjust the speed of the movements. Also implementing the H-Bridge driver helped electronically, in the control of both directions for each motor. One more result is that the robotic arm was programmable to pick up a small object. In conclusion this project served its purpose in showing the many applications that it can improve. It also proved that you change a basic task and create a door to unlimited possibilities.

F1.10 Discussion

In this project the use of a simple robotic arm kit is improved. This project takes the original functionality of a basic robotic arm out of a kit and transforms them to a different control system, where it becomes possible to do a range of different and more complex operations with the arm that was not previously possible. The robotic arm can be implemented in

the medical field through a variety of ways. It can help researchers improve their study and testing for prosthetic arm. It can also help improve the way a hospital runs.

F1.11 What Would You Do Next?

Study the movements of human arm and begin to simulate the physics that are placed in to prosthetic arms.

F1.12 Acknowledgements

Special thanks to my mentors, Mr. Joseph Svejkosky and Mr. Henry Noble for advice and help with obtaining certain materials. Also a special thanks to my mother for all her moral support.

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F2. Fruity Carbs, Sade Foster, Grade 10

F2.1 Abstract

The purpose of this project is to find out which fruit juice has the most carbohydrates in it? My hypothesis is if I mix 4mL of fruit juice and 1mL of iodine solution then I will be able to determine that white grape juice will turn the darkest color because it has the highest carbohydrates. My independent variable is the juice and the dependent variable is the amount of sugar in the juice. Carbohydrates are organic compounds composed of carbon, hydrogen and oxygen. The methods are as follows: first put on safety goggles, second make boiling water, third put 4mL of a fruit juice in a test tube, forth add 1mL of iodine solution to the test tube, fifth stir it, sixth put the test tubes in the water, seventh wait several minutes or wait till the color change, lastly record my results and do the same for all fruit juices. The results were the orange juice had the lowest carbohydrates. It changed to the color orange, which mean it was low. The white-grape juice had the highest carbohydrates. It changed to brown. The conclusion is the hypothesis was right. When the iodine was added to the fruit juices and heated, white-grape turned brown,

which indicated that it had the most carbohydrates in it. It was very subjective. Which mean it was visual check.

F2.2 Introduction

The purpose of this project is to find out which fruit juice has the most carbohydrates in it. My question: Is there a different amount of carbohydrates in different types of fruit juices? My hypothesis is If I mix 4mL of fruit juice and add 1mL of iodine solution then I will be able to determine that white-grape juice will turn the darkest because it has the highest carbohydrates. This project means a lot to me because diabetes runs in my family. Such as my uncles and aunt is diabetics and I wanted to learn more about diabetics. I wanted to see what juice is healthy for them and what's not. They all have type 2 diabetes. So that's why I was very interested in this topic.

F2.3 What is Diabetes?

Type 1diabetes is when you have it when you are born and then type 2 diabetes is when you get it later in life. High blood sugar is when an excessive amount of glucose circulates in the blood plasma. Sign of diabetes is you always have to pee, you always tired or hungry all the time. Type 1 diabetes has to take insulin because the beta cells in the pancreas are not making insulin. Type 2 does not have to take insulin. If a person's sugar drops too low, they could go into a diabetic coma. In order to bring balance to that person sugar, they require a quick fix of sugar that is found in orange juice in other sweet liquid. Orange juice contains a high concentration of sugar that is readily used by the body. What is the relationship between Insulin and glucose? Glucose and insulin cannot exist in healthy person without each other. They are interdependent on each other. Insulin is a protein hormone that acts as a keeper the detector of sugar in the body. When the sugar needs to be released to be converted into energy, insulin accesses the increasing blood sugar and converts it into energy.

F2.4 What are Carbohydrates?

Carbohydrates are organic compounds composed of carbon, hydrogen, oxygen in a ratio of about 2 hydrogen atoms and one oxygen in a ratio the fructose is a sugar for fruits. There are 3 classification of carbohydrates which are Monosaccharide, Disaccharides, and Polysaccharides. Monosaccharide contains a single unit. Monosaccharide is written as ($CH_20)_n$. Disaccharides contain two units. Polysaccharides contain three or more units. Saccharide means sugar. Examples of Monosaccharide are glucose, fructose. Examples of Disaccharide are lactose (milk) and sucrose (table sugar). Carbohydrates are broken down into a molecule called glucose. Carbohydrates are also composed of starches and sugars.

F2.5 What are Simple Sugars?

Glucose is a main source of energy for cells. It is a carbohydrates and a monosaccharide sugar. Simple Sugars are carbohydrates that are quickly absorbed by the body to produce energy. Some simple sugars are as follows milk, fruit, honey, juice, table sugar. Simple sugar are broken down quickly producing a rapid increase in blood sugar levels. Complex Sugars = 2 simple sugars put together. Complex Sugars are starchy vegetables such a potatoes, peas and corn etc. Complex Sugar take longer to break down and process in the body because of their structure. Sucrose and glucose are both sugars but each affects the body differently. Sucrose is table sugar. Glucose is the chemical made when we digest starches and sugars from carbohydrates such as

bread and potatoes. Sucrose is found in foods such as candies, jam, and cookies. Glucose travels into the bloodstream to fuel the body. This process forms chemical reaction which helps muscles to move and the brain to function. There are different types of sugars including table sugar, which had the chemical name sucrose. Glucose is a simpler molecule then sucrose. Both contain carbon, hydrogen, oxygen atoms. Even glucose itself can be in different forms and have different properties depending on how the atoms are arranged. What is Glucose Made Of? There are six carbon atoms on a glucose molecule. Attached to the carbon atoms are 12 hydrogen atoms. Also attached to the carbon atoms are six oxygen atoms.

F2.6 What is Iodine?

Iodine solution is a water based solution of iodine and potassium iodide. Iodine is a nonmetallic halogen element occurring at ordinary temperatures as a grayish-black crystalline solid that sublimes to dense violet vapor when heated. Iodine is a mixture of mostly copper sulfate and sodium. When iodine is mixed and heated a color change identifies the relative construction of sugar in the solution. Iodine only tests simple sugars fructose and glucose. More complex sugars sucrose and lactose can be identified. The reason why I used iodine for this experiment is because the chemical compound causes color change when mixed with sugar.

F2.7 Fruits

The reason why I used the fruit juices is the experiment called for light/ clear color fruit juices. I also asked some of my family members what kind of fruit juices they drink most often. Most of them said they juices that I picked. So that's another reason why I pick those juices. A natural juice is what you make at home. Processed and bottled is what you can buy at the store. The difference between the two is natural juices have more vitamins in it and bottled juices has more preservatives. If I used natural juices I would get different results. One serving of grapes (approx. 126 grams) has 23 grams of sugar. 1 large apple has 20 grams of sugar and 1 navel orange has 19 grams of sugar. So grapes still had the highest amount of sugar in it. The sugar that's in fruits is Fructose. Fructose is a monosaccharide (simple sugar) which the body can use for energy because it does not cause blood sugar rise tremendously. Fructose is found in plants which are similar to sucrose. Fructose is also called levulose. Fructose is one of the main sugars from fruit. Fructose has the same molecular formula as glucose but contains a ketone rather that an aldehyde functional group. Fructose occurs naturally in both fruits and honey and is found combined with glucose in the disaccharide sucrose called cane sugar. Fructose is the sweetest sugar.

F2.8 What is Starch?

Starch a polysaccharide carbohydrates consisting of a large number of glucose monosaccharide units joined together by glycosidic bonds found especially in seeds, bulbs, and tubers. Starch chains pack closely together in a potato or a pasta noodle. When you eat such foods enzymes in your body break down the starch, making glucose available as a nutrient for your cells. Glucose that is needed right away is stored as a glycogen. When you become active glycogen breaks a-parts and glucose molecules give you energy. What happens when you mix iodine and starch? Iodine acts as a stain when applied to starch. It turns the starch a dark purple. The iodine fits into the center of the complex starch molecules and gives it its distinct color. The reaction is due to the formation of polyiodide chains from the reaction of starch and iodine. The amylose in starch forms helices where iodine molecules assemble forming a dark blue or black

color. When starch is broken down into smaller carbohydrates units the black or blue color is not produced. Iodine solution is used to test for starch. The details of this reaction are not yet fully known, but it is thought that iodine fits inside the coils of amylase. The change transfer between the iodine and starch and the energy level spacing's in the resulting complex correspond to the absorption spectrum in the visible light region. The strength of the resulting blue color depends on the amount of amylose present.

F2.9 Materials and Methods

F2.9.1 Materials

1. Iodine Solution
2. Test tube holder
3. Test tube
4. Lime juice
5. White grape juice
6. Orange Juice
7. Apple juice
8. Corning Wear Mug
9. Safety Goggles
10. Tongs

F2.9.2 Methods

1. Put on safety goggles
2. Make boiling water on the hot plate
3. Put 4mL of a fruit juice in a test tube
4. Add 1mL of iodine solution to the test tube
5. Stir it well
6. Put the test tubes in the water
7. Wait several of min. or wait till the color change
8. Record my results
9. Do the same for all fruit juice

F2.10 Results

Figure F-4 Materials

Figure F-5 Before heated

Figure F-6 Being Heated

Figure F-7 After Heated

Figure F-8 Juice Results Comparison

The orange juice and lime juice had the lowest carbohydrates. It's changed to the color orange which mean its low. The white- grape juice had the high carbohydrates.   It's changed to brown.

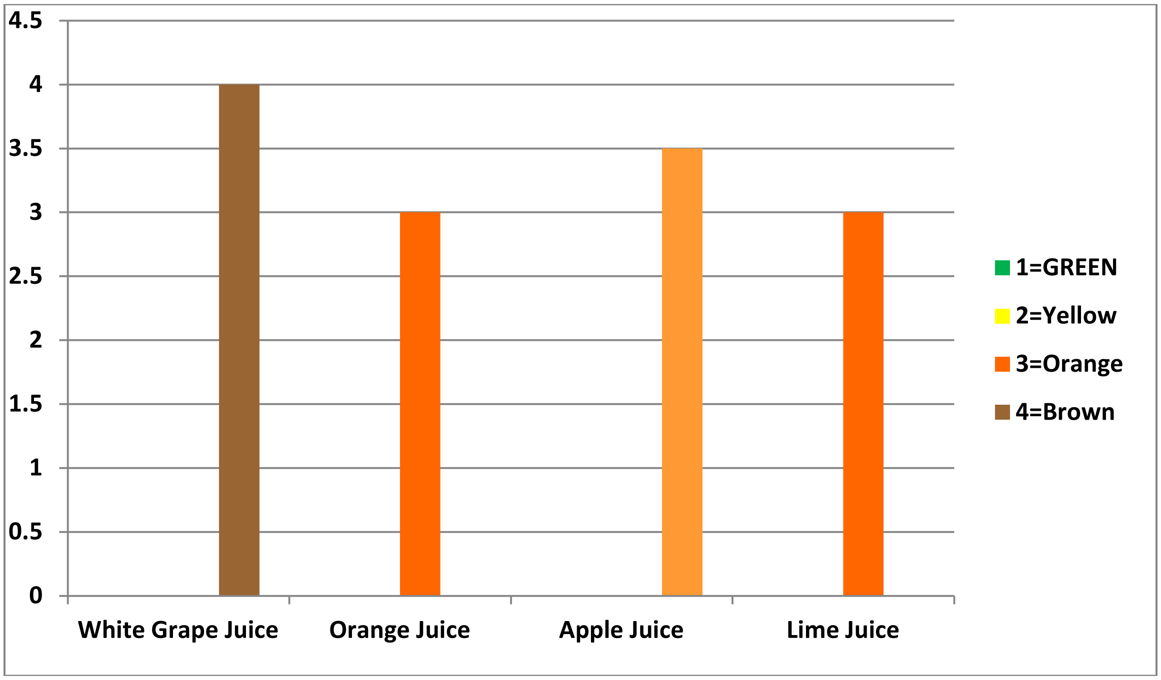

Figure F-9 Juice Carbohydrate Chart

The numbers on the graph shows which juice had the largest amount of carbohydrates with 0 being the lowest and 4 being the highest.

F2.11 Discussion and Conclusion

When iodine is mixed with starch it turns the starch from white to purple. The reaction is due to the formation of polyiodide chains from the reaction of starch and iodine. During the

experiment it was observed that the color of the juices changed due to the amount of carbohydrates/sugar. In order to measure the color changes, a scale was developed ranging from 0 to 4.5 with 0 being no change to 4.5 being the most change. All of the juices that were measured were between 3 and 4. White grape went to 4. Apple Juice went to 3.5. Orange and lime went to 3.The hypothesis that I had was right. When the iodine was added to the fruit juices and heated, white-grape turned brown, which indicated that it had the most carbohydrates in it. It was very subjective. Which mean it was visible check.

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F2.13 Acknowledgements

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7. Photos by Tina Foster

F3. Which Shape of Wing Creates the Most Lift, Khayln Miller, Grade 10

F3.1 Abstract

The purpose of this experiment was to find out which wing shape would produce the most lift between rectangular, elliptical, delta, and swept back shaped wings. My hypothesis is if I test them in a wind tunnel at three different angles, then record how much lift each produces at each angle, the elliptical wings will produce the most lift for each angle because this design reduces drag and can create lift faster than other airfoils because of its unique design.

My procedure was as follows: First I placed the first airfoil in the wind tunnel at a 5 degree angle. Next I turned on the wind tunnel at half speed. After that I recorded how much lift is produced. Next I switched the wind tunnel to full speed and recorded how much lift is produced. Do this three times and take the average for full and half speed. Then I changed the angle of attack to 15 degrees and 25 degrees and repeat steps 2-6. Finally I repeated steps 1-6 for the other three airfoils.

My hypothesis was disproven. The elliptical shaped wing didn't have the most lift at each angle of attack. The delta and swept back shaped wings produced more lift than the elliptical shaped did. I believe my hypothesis was disproven because the swept back shaped wing creates

little drag and the delta shaped wing creates even less drag and that there is a correlation between the drag and the lift. Also the different designs could have caused my hypothesis to be wrong.

F3.1.1 Question

Since the shape of aircraft wings determine how much weight it can lift, which wing shape produces the greatest lift?

F3.1.2 Hypothesis

There are four different types of wing shapes I am testing for, Rectangular, Elliptical, Swept, and Delta shaped wings. If I test them in a wind tunnel at three different angles, then record how much lift each produces at each angle, I think the elliptical wings will produce the most lift for each angle because this design provides lift without a lot of forward momentum. The elliptical wing reduces drag and can create lift faster than other airfoils because of its unique design. The dependent variable in this project is the lift. The Independent variable is the angle of attack.

F3.2 Introduction

F3.2.1 Background

The reason I chose this project is because flight interests me very much. I’ve always been curious about how planes fly, and I know now, you need lift. I want to study this particular subject, so I want to focus on which wings can provide the most lift.

F3.2.2 What is Lift

> “The amount of lift generated by an object depends on the size of the object. Lift is an aerodynamic force and therefore depends on the pressure variation of the air around the body as it moves through the air. The total aerodynamic force is equal to the pressure times the surface area around the body. Lift is the component of this force perpendicular to the flight direction. Like the other aerodynamic force, drag, the lift is directly proportional to the area of the object. Doubling the area doubles the lift.” (NASA)
>
> “There are several different areas from which to choose when developing the reference area used in the lift equation. Since most of the lift is generated by the wings, and lift is the force perpendicular to the flight direction, the logical choice is the wing planform area. The platform area is the area of the wing as viewed from above the wing, looking along the "lift" direction. It is a flat plane, and is NOT the total surface area (top and bottom) of the entire wing, although it is almost half that number for most wings. We could, in theory, use the total surface area as the reference area. The total surface area is proportional to the wing planform area. Since the lift coefficient is determined experimentally, by measuring the lift and measuring the area and performing the necessary math to produce the coefficient, we are free to use any area which can be easily measured. If we choose the total surface area, the computed coefficient has a different value than if we choose the wing planform area, but the lift is the same, and the coefficients are related by the ratio of the areas.” (NASA)
>
> “Lift is the force that directly opposes the weight of an airplane and holds the airplane in the air. Lift is generated by every part of the airplane, but most of the lift on a normal airliner is generated by the wings. Lift is a mechanical aerodynamic force produced by

the motion of the airplane through the air. Because lift is a force, it is a vector quantity, having both a magnitude and a direction associated with it. Lift acts through the center of pressure of the object and is directed perpendicular to the flow direction. There are several factors which affect the magnitude of lift." (NASA)

"Lift occurs when a moving flow of gas is turned by a solid object. The flow is turned in one direction, and the lift is generated in the opposite direction, according to Newton's Third Law of action and reaction. Because air is a gas and the molecules are free to move about, any solid surface can deflect a flow. For an aircraft wing, both the upper and lower surfaces contribute to the flow turning." (NASA)

Lift Equation – L= CI x P x V^2/2 x A
Lift= coefficient x (density x velocity squared/two) x wing area

For this project, I'll be measuring lift in grams. The bar that I place my wings on in the wind tunnel has a strain gauge attached to it and by using it an electrical circuit can measure the strain put on it by the lift force. This is measured in volts, but I used curves (force versus voltage) to change the voltage reading in to grams

Lift = (volt reading / 9)*100g

F3.3 Angle of Attack

As a wing moves through the air, the wing is inclined to the flight direction at some angle. The angle between the chord line and the flight direction is called the angle of attack and has a large effect on the lift generated by a wing. When an airplane takes off, the pilot applies as much thrust as possible to make the airplane roll along the runway. But just before lifting off, the pilot "rotates" the aircraft. The nose of the airplane rises, increasing the angle of attack and producing the increased lift needed for takeoff.

F3.4 What are Wings? / Different Airfoils

An airfoil whose principal function is providing lift.

"Rectangular Wing: The rectangular wing, sometimes referred to as the "Hershey Bar" wing in reference to the candy bar it resembles, is a good general purpose wing. It can carry a reasonable load and fly at a reasonable speed, but does nothing superbly well. It is ideal for personal aircraft as it is easy to control in the air as well as inexpensive to build and maintain." (NASA)

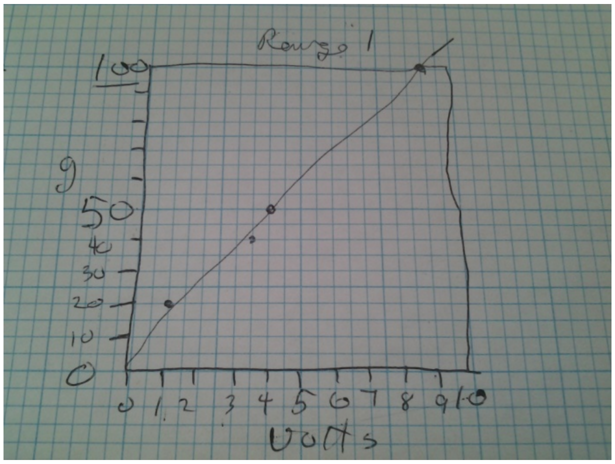

Figure F-10 Calibrations

> "Elliptical wing: The elliptical wing is similar to the rectangular wing and was common on tail-wheel aircraft produced in the 1930s and 40s. It excels however in use on gliders, where its long wingspan can capture the wind currents easily, providing lift without the need for a lot of forward momentum, or airspeed." (NASA)
>
> "Swept Wing: The swept wing is the "go to" wing for jet powered aircrafts. It needs more forward speed to produce lift than the rectangular wing, but produces much less drag in the process, meaning that the aircraft can fly faster. It also works well at the higher altitudes, which is where most jet aircraft fly." (NASA)
>
> "Delta Wing: The delta wing advances the swept wing concept, pulling the wings even further back and creating even less drag. The downside to this however is that the aircraft has to fly extremely fast for this wing to be affective. This is why it's only found on supersonic aircraft (aircraft that flies faster than the speed of sound) such as fighter jets and the space shuttle orbiter. There were also two commercial passenger jets that used this wing design, the Russian TU-144 and BOAC's Concorde, both of which could cruise at supersonic speeds." (NASA)

Wing Equations:

- Rectangular: A=b*h (base*height)

4.7in*1.5in= **7.05 inches squared**

- Delta: A=1/2*b*h

½*3.8in*3.7in = **7.03 inches squared**

- Swept Back: A=Wing Span*Average Chord*2

Average Chord: (root cord + tip cord) / 2

1in*3.5in*2 = **7 inches squared**

- Elliptical: A= (3.14*span*chord) / 4

(3.14*6in*1.5in) / 4 = **7.07 inches squared**

F3.5 What is Drag?

"Drag is the aerodynamic force that opposes an aircraft's motion through the air. Drag is generated by every part of the airplane (even the engines!)." (NASA)

"Drag is a mechanical force. It is generated by the interaction and contact of a solid body with a fluid (liquid or gas). It is not generated by a force field, in the sense of a gravitational field or an electromagnetic field, where one object can affect another object without being in physical contact. For drag to be generated, the solid body must be in contact with the fluid. If there is no fluid, there is no drag. Drag is generated by the difference in velocity between the solid object and the fluid. There must be motion between the object and the fluid. If there is no motion, there is no drag. It makes no difference whether the object moves through a static fluid or whether the fluid moves past a static solid object." (NASA)

"Drag is a force and is therefore a vector quantity having both a magnitude and a direction. Drag acts in a direction that is opposite to the motion of the aircraft. Lift acts perpendicular to the motion. There are many factors that affect the magnitude of the drag. Many of the factors also affect lift but there are some factors that are unique to aircraft drag." (NASA)

"We can think of drag as aerodynamic friction, and one of the sources of drag is the skin friction between the molecules of the air and the solid surface of the aircraft. Because the skin friction is an interaction between a solid and a gas, the magnitude of the skin friction depends on properties of both solid and gas. For the solid, a smooth, waxed surface produces less skin friction than a roughened surface. For the gas, the magnitude depends on the viscosity of the air and the relative magnitude of the viscous forces to the motion of the flow, expressed as the Reynolds number. Along the solid surface, a boundary of low energy flow is generated and the magnitude of the skin friction depends on conditions in the boundary layer." (NASA)

"We can also think of drag as aerodynamic resistance to the motion of the object through the fluid. This source of drag depends on the shape of the aircraft and is called form drag. As air flows around a body, the local velocity and pressure are changed. Since pressure is a measure of the momentum of the gas molecules and a change in momentum produces a force, a varying pressure distribution will produce a force on the body. We can determine the magnitude of the force by integrating (or adding up) the local pressure times the surface area around the entire body. The component of the aerodynamic force that is opposed to the motion is the drag; the component perpendicular to the motion is the lift. The lift and drag force act through the center of pressure of the object." (NASA)

F3.6 What are Wind Tunnels?

Figure F-11 Wind Tunnel Control Board
The wind tunnel I am using for my project is an Aerostream Wind Tunnel

"Aerodynamicists use wind tunnels to test models of proposed aircraft. In the tunnel, the engineer can carefully control the flow conditions which affect forces on the aircraft. By making careful measurements of the forces on the model, the engineer can predict the forces on the full scale aircraft. And by using special diagnostic techniques, the engineer can better understand and improve the performance of the aircraft." (NASA)

"Wind tunnels are usually designed for a specific purpose and speed range. There are special tunnels for propulsion, icing research, subsonic, supersonic, and hypersonic flight, and even full scale testing. A wind tunnel may be open and draw air from outside the tunnel into the test section and then exhaust back to the outside, or the tunnel may be closed with the air recirculation inside the tunnel. The tunnel in the figure is a closed tunnel which we are viewing from above. The air inside the tunnel is made to move by the fan on the far side of the tunnel. In this figure, air continuously moves counter-clockwise around the circuit, passing over the model that is mounted in the test section." (NASA)

"Wind tunnels usually have powerful fans to move the air through the tube. The object being tested is placed in the tunnel so that it will not move. The air moving around the still object shows what would happen if the object were moving through the air. The object can be a smaller-scale model of a vehicle, one piece of a vehicle, a full-size aircraft or spacecraft, or even a common object like a tennis ball. Usually, the object carries special instruments to measure the forces produced by the air on the object. Engineers also study how the air moves around the object by injecting smoke or dye into the tunnel and photographing its motion around the object. Improving the flow of air around an object can increase its lift and decrease its drag." (NASA)

F3.7 Physics Behind How an Airplane Flies

Newton's Three Laws of Motion:

I. Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.

II. The relationship between an object's mass m, its acceleration a, and the applied force F is F = ma. Acceleration and force are vectors; in this law the direction of the force vector is the same as the direction of the acceleration vector.

III. For every action there is an equal and opposite reaction.

F3.8 Other Forces on an Airplane:

- Weight - Weight is a force that is always directed toward the center of the earth. The magnitude of the weight depends on the mass of all the airplane parts, plus the amount of fuel, plus any payload on board (people, baggage, freight, etc.). The weight is distributed throughout the airplane. But we can often think of it as collected and acting through a single point called the center of gravity. In flight, the airplane rotates about the center of gravity.
- Thrust - To overcome drag, airplanes use a propulsion system to generate a force called thrust. The direction of the thrust force depends on how the engines are attached to the aircraft. On some aircraft, such as the Harrier, the thrust direction can be varied to help the airplane take off in a very short distance. The magnitude of the thrust depends on many factors associated with the propulsion system including the type of engine, the number of engines, and the throttle setting. For jet engines, it is often confusing to remember that aircraft thrust is a reaction to the hot gas rushing out of the nozzle. The hot gas goes out the back, but the thrust pushes towards the front. Action <--> reaction is explained by Newton's Third Law of Motion. The motion of the airplane through the air depends on the relative strength and direction of the forces shown above. If the forces are balanced, the aircraft cruises at constant velocity. If the forces are unbalanced, the aircraft accelerates in the direction of the largest force.

F3.9 Bernoulli’s Principle

Bernoulli's Principle- Works on the idea that as a wing passes through the air, its shape make the air travel more over the top of the wing than beneath it. This creates a higher pressure beneath the wing than above it. The pressure difference cause the wing to push upwards and lift is created.

F3.10 Materials and Methods

F3.10.1 Materials

1. Styrofoam Board
2. X-Acto Knife
3. Ruler
4. Pencil
5. Model Size rectangular wings made out of Styrofoam board
6. Model Size elliptical wing made out of Styrofoam board
7. Model Size plane swept wing made out of Styrofoam board
8. Model Size plane delta wing made out of Styrofoam board
9. Wind Tunnel
10. Four Screws & Nuts
11. Protractor

F3.10.2 Methods

1. Place the first airfoil in the wind tunnel at a 5 degree angle.
2. Turn on the wind tunnel at half speed (20 mph).
3. Record how much lift is produced.
4. Switch the wind tunnel to full speed (40 mph).
5. Record how much lift is produced.
6. Do this three times and take the average for full and half speed.
7. Change the angle of attack to 15 degrees and 25 degrees and repeat steps 2-6.
8. Repeat steps 1-6 for the other three airfoils.

F3.11 Results

These are my charts from my old data when the surface areas were not approximate and the edges on the wings were not as smooth as my new wings. I also measured the lift in volts instead of grams.

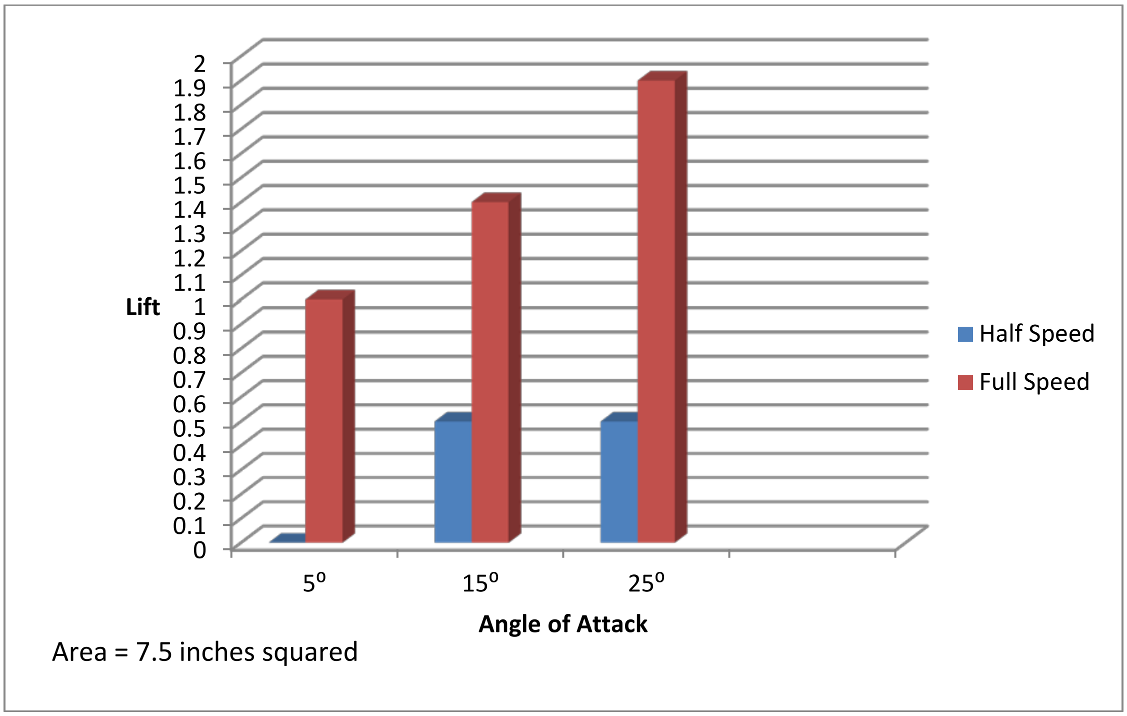

Figure F-12. Swept Back Wing Chart

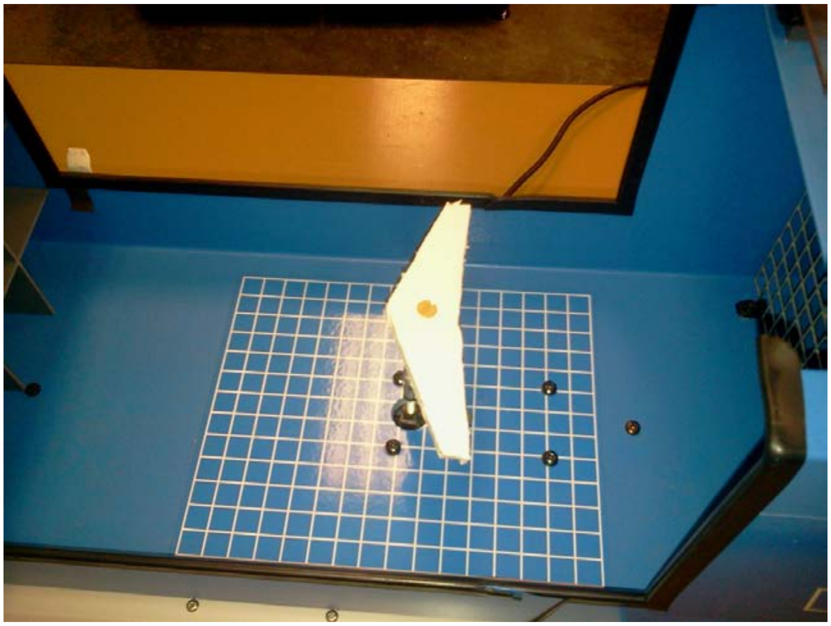

Figure F-13 Swept Back Wing Model

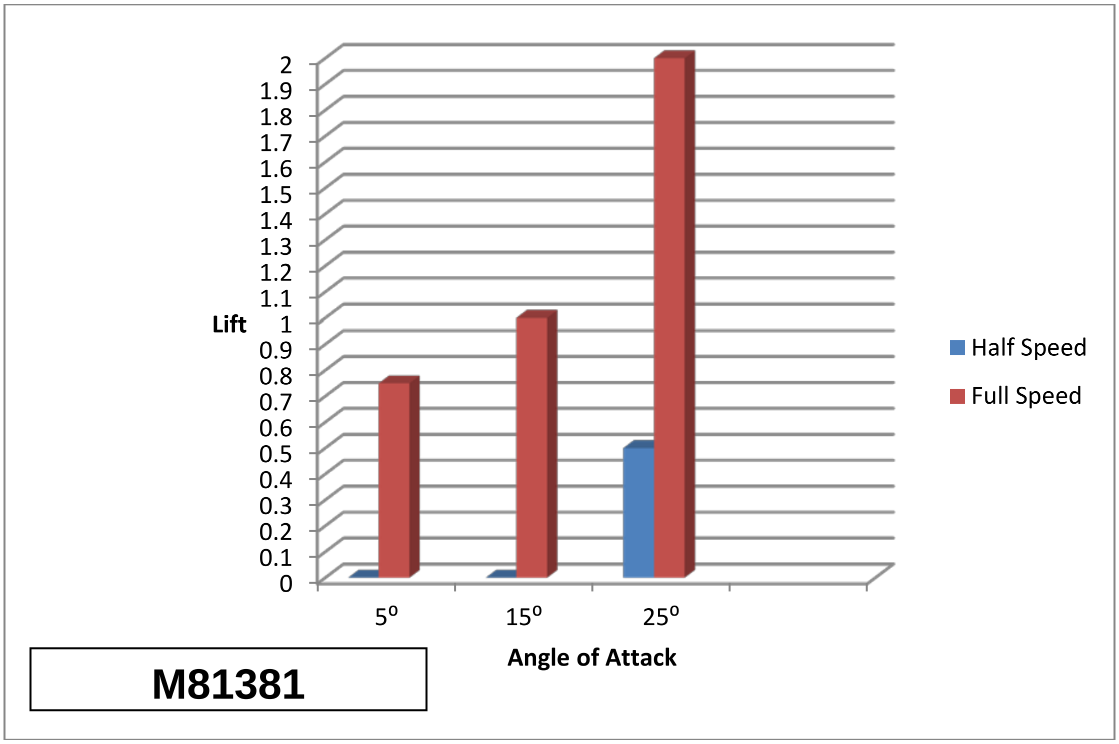

Figure F-14 Delta Wing Chart

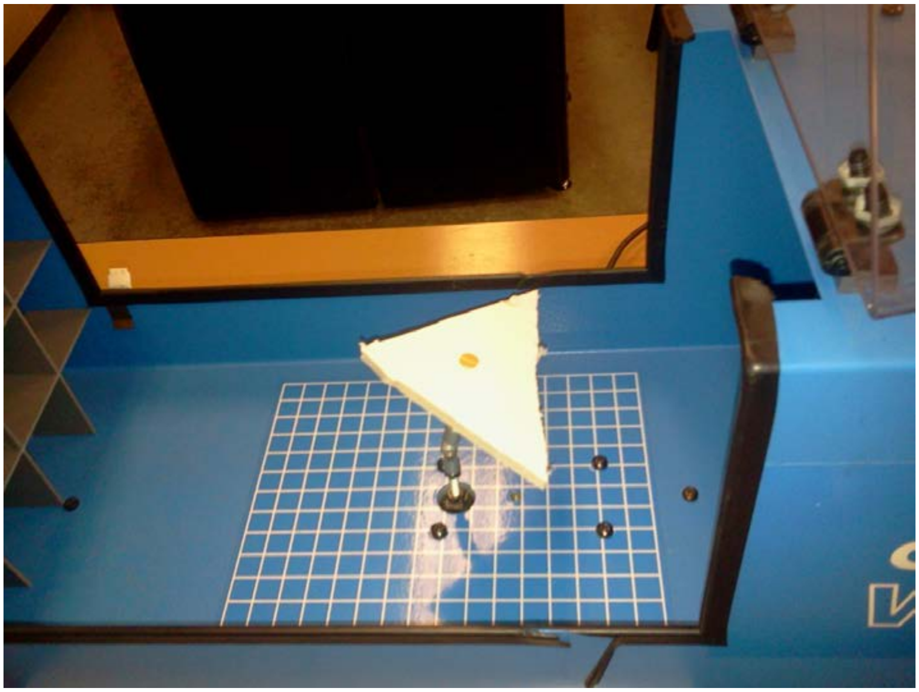

Figure F-15 Delta Wing Model

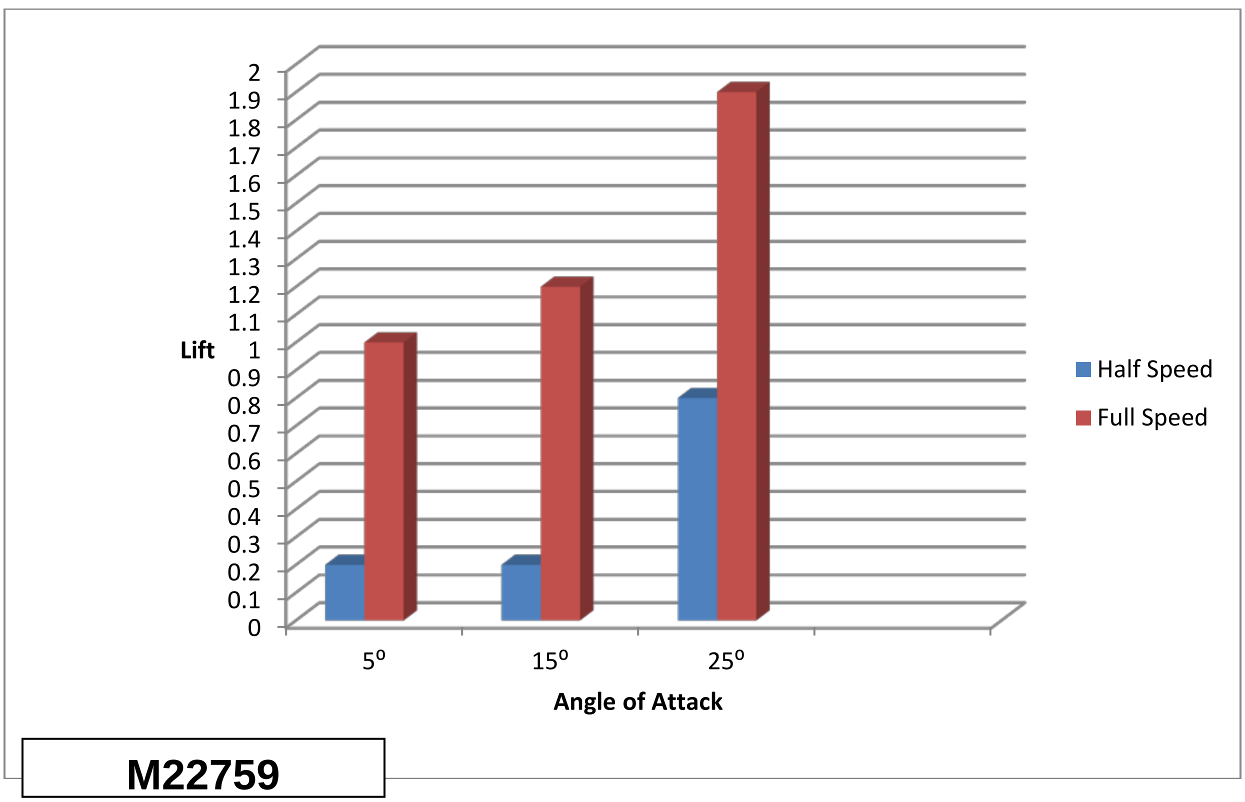

Figure F-16 Rectangular Wing Chart

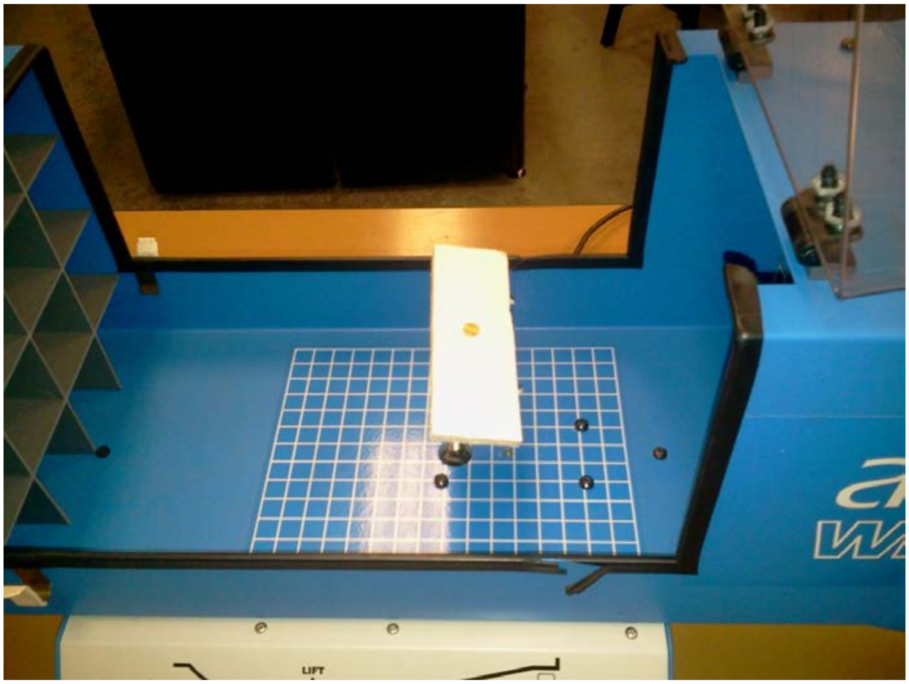

Figure F-17 Rectangular Wing Model

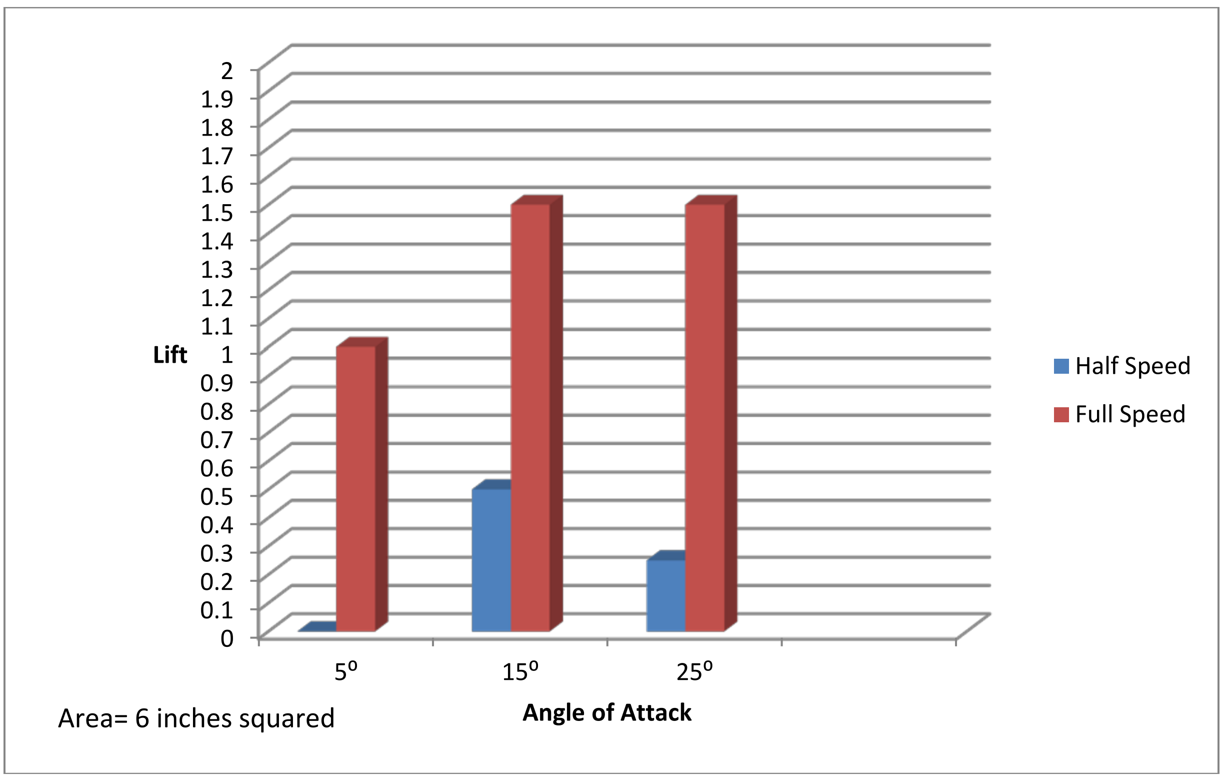

Figure F-18 Elliptical Wing Chart

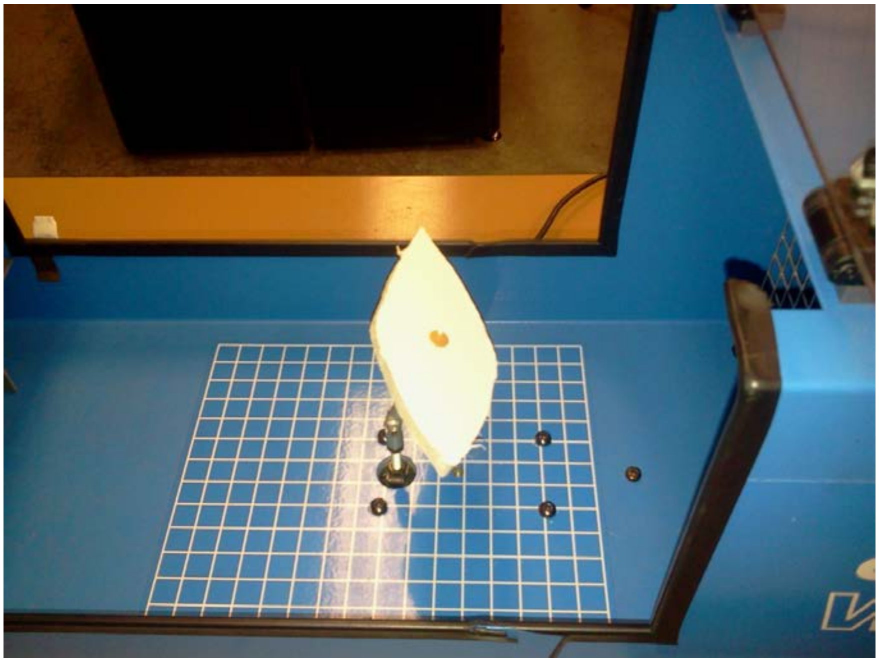

Figure F-19 Elliptical Wing Model

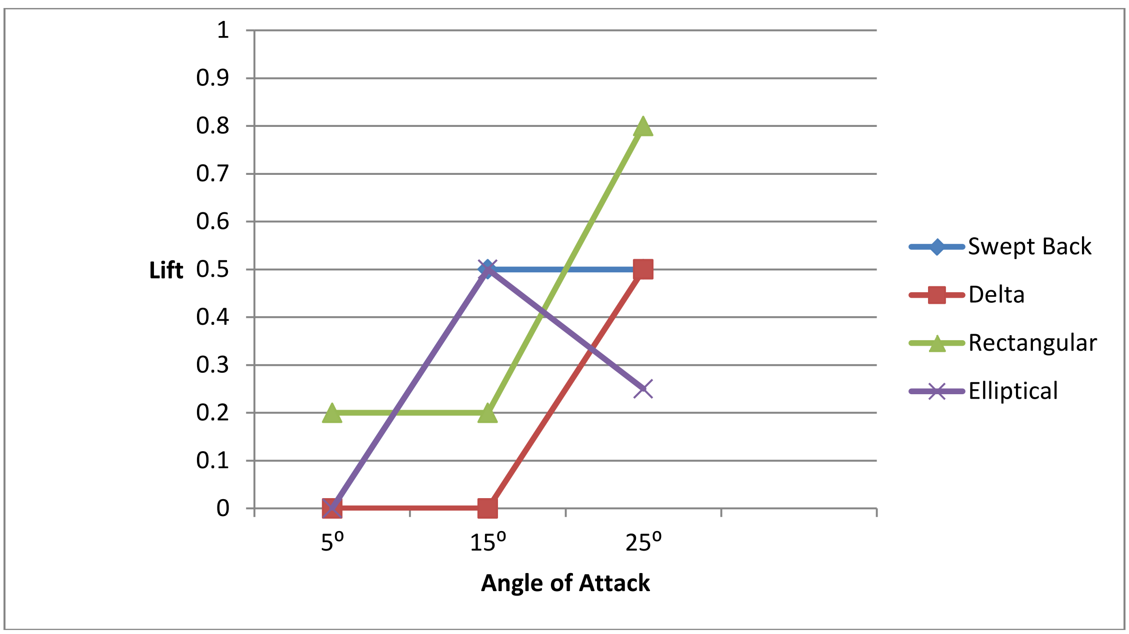

Figure F-20 Half Speed Chart

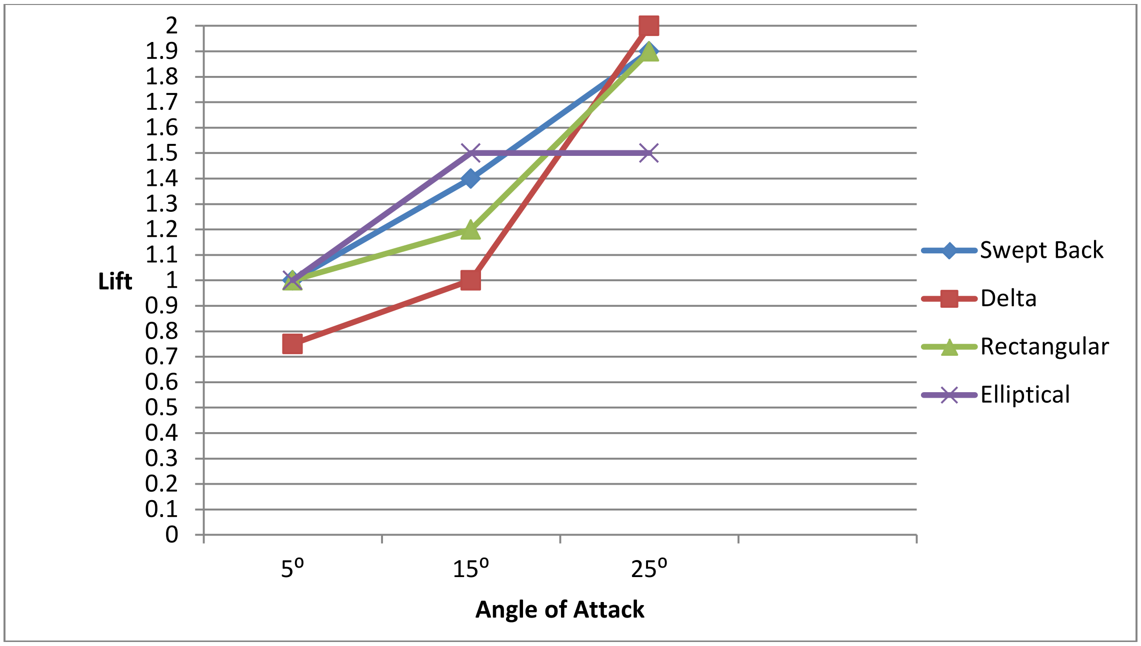

Figure F-21 Full Speed Chart

These are my results from when I did this project over with all the wings having an area of approximately 7 inches squared, smoother edges, and lift is measured in grams.

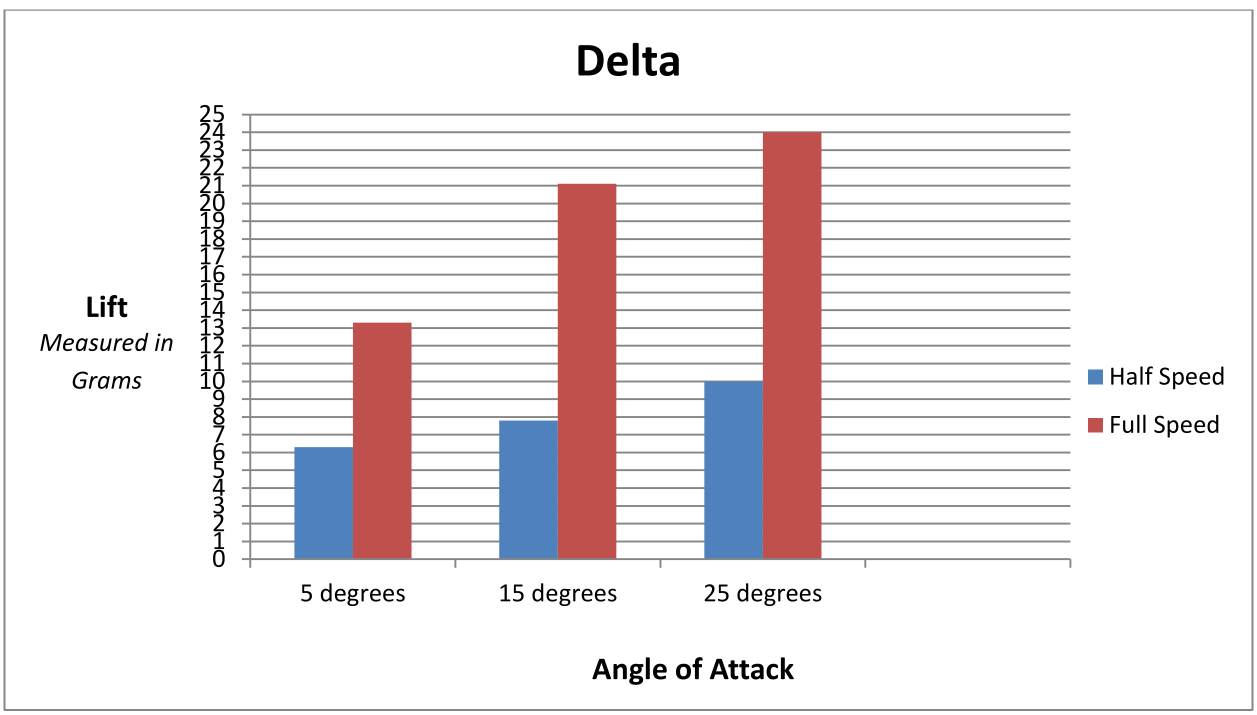

Figure F-22 Delta Wing Chart with 7 Inches Squared and Smoother Edges

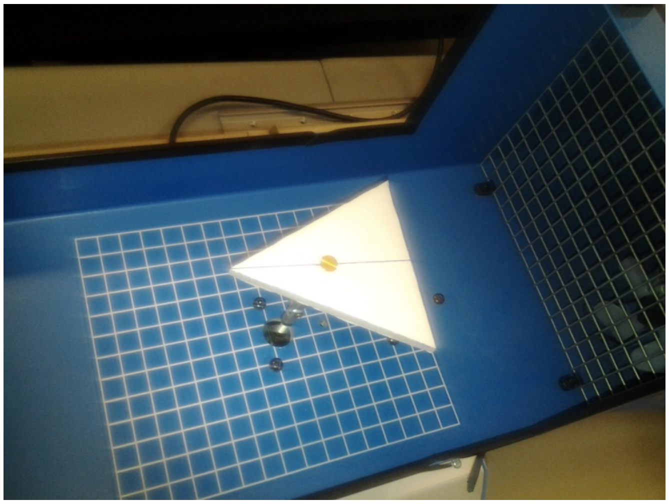

Figure F-23 Delta Wing Lift Model with 7 Inches Squared and Smoother Edges

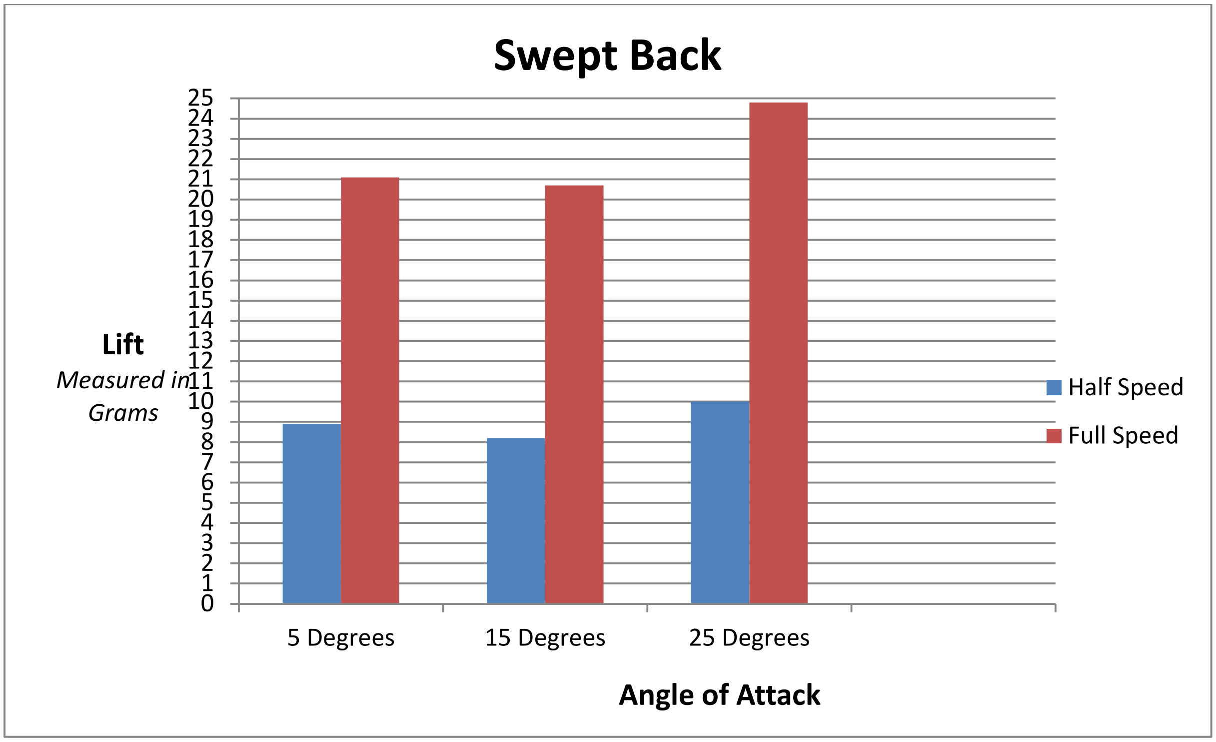

Figure F-24 Swept Back Wing Chart with 7 Inches Squared and Smoother Edges

Figure F-25 Swept Back Wing Model with 7 Inches Squared and Smoother Edges

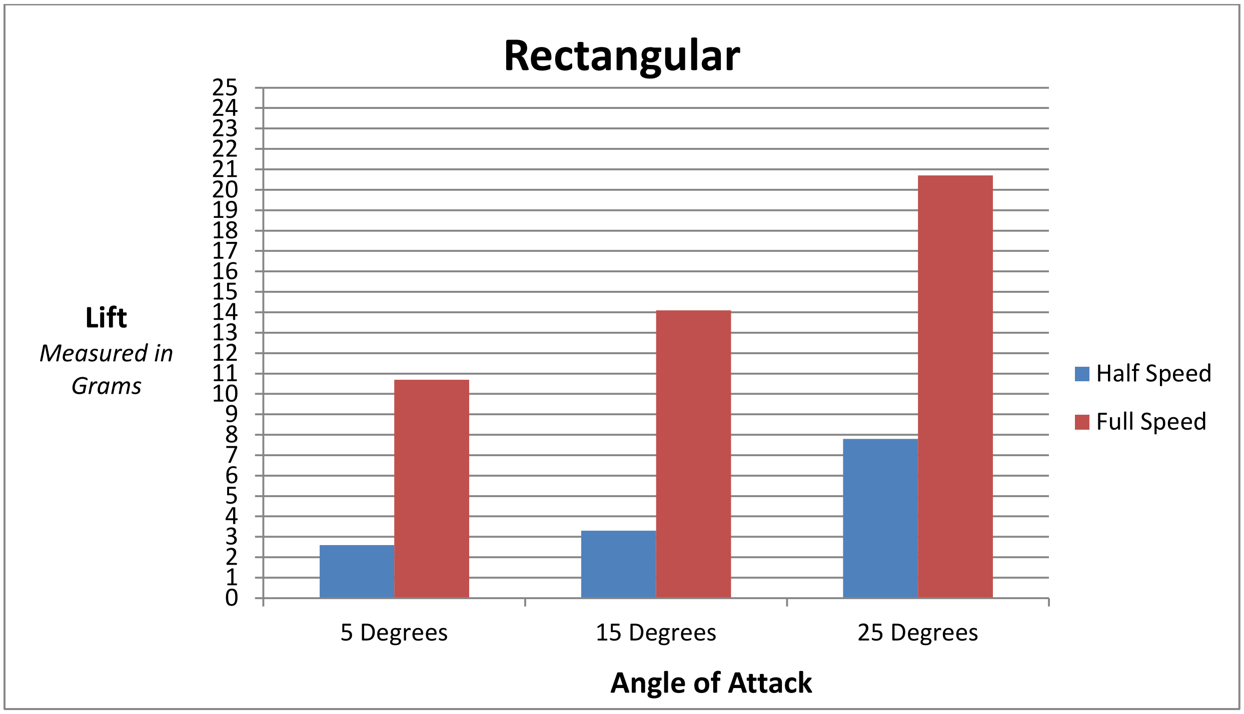

Figure F-26 Rectangular Wing Chart with 7 Inches Squared and Smoother Edges

Figure F-27 Rectangular Wing Model with 7 Inches Squared and Smoother Edges

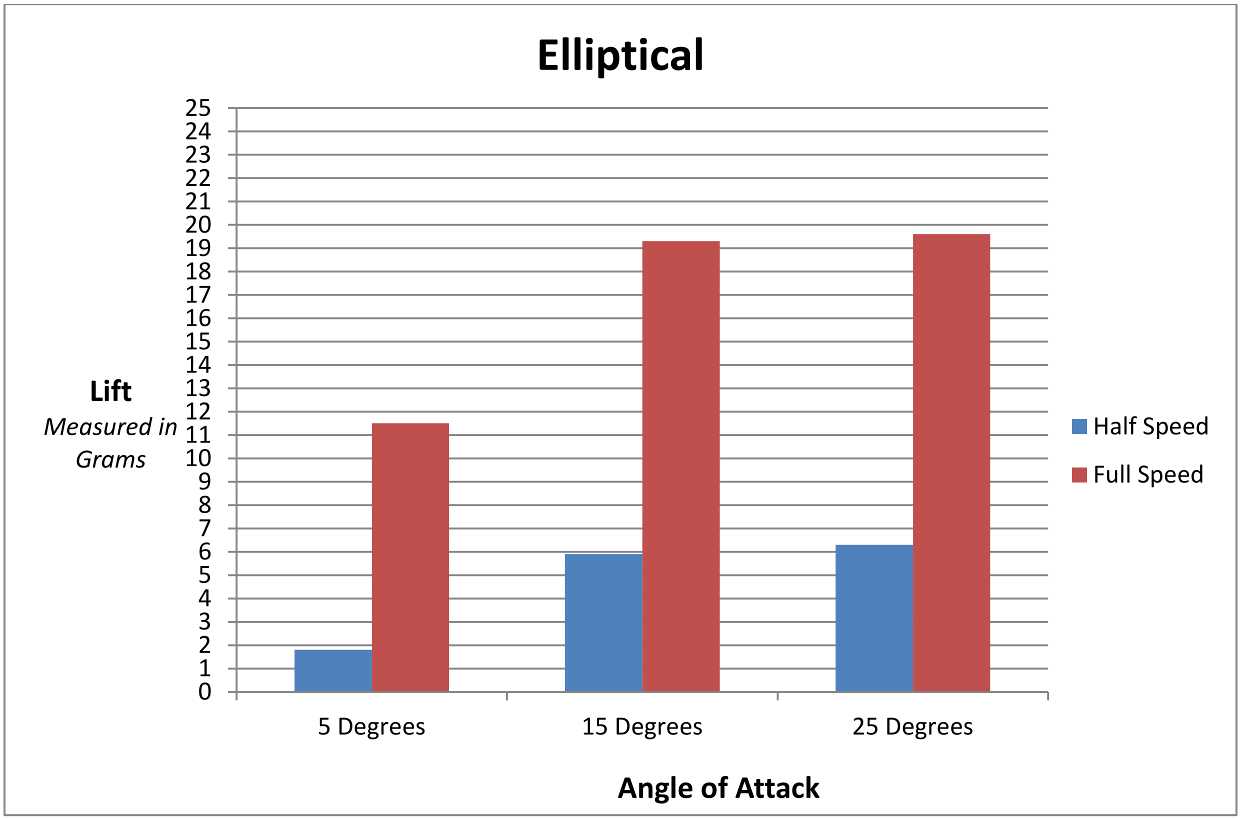

Figure F-28 Elliptical Wing Chart with 7 Inches Squared and Smoother Edges

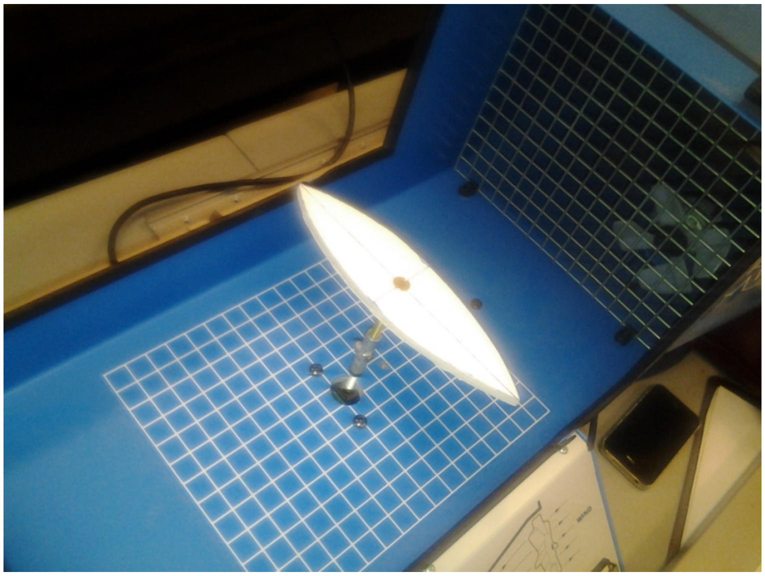

Figure F-29 Elliptical Wing Model with 7 Inches Squared and Smoother Edges

Table F-1 Delta Wing Results

5 Degrees	*Volts*	*Grams*
Half Speed #1	0.5	5.6
Half Speed #2	0.7	7.8
Half Speed #3	0.5	5.6
Full Speed #1	1	11.1
Full Speed #2	1.5	16.7
Full Speed #3	1.1	12.2

15 Degrees	*Volts*	*Grams*
Half Speed #1	0.6	6.7
Half Speed #2	0.7	7.8
Half Speed #3	0.8	8.9
Full Speed #1	1.8	20
Full Speed #2	1.9	21.1
Full Speed #3	2	22.2

25 Degrees	*Volts*	*Grams*
Half Speed #1	0.8	8.9
Half Speed #2	0.9	10
Half Speed #3	1	11.1
Full Speed #1	2.1	23.3
Full Speed #2	2.2	24.4
Full Speed #3	2.2	24.4

Table F-2 Swept Back Wing Results

5 Degrees	*Volts*	*Grams*
Half Speed #1	0.7	7.8
Half Speed #2	0.8	8.9
Half Speed #3	0.9	10
Full Speed #1	1.9	21.1
Full Speed #2	1.9	21.1
Full Speed #3	1.9	21.1

15 Degrees	*Volts*	*Grams*
Half Speed #1	0.6	6.7
Half Speed #2	0.8	8.9
Half Speed #3	0.8	8.9
Full Speed #1	1.8	20
Full Speed #2	1.9	21.1
Full Speed #3	1.9	21.1

25 Degrees	*Volts*	*Grams*
Half Speed #1	0.8	8.9
Half Speed #2	0.9	10
Half Speed #3	1	11.1
Full Speed #1	2.1	23.3
Full Speed #2	2.2	24.4
Full Speed #3	2.4	26.7

Table F-3 Rectangular Wing Results

5 Degrees	*Volts*	*Grams*
Half Speed #1	0.1	1.1
Half Speed #2	0.3	3.3
Half Speed #3	0.3	3.3
Full Speed #1	0.9	10
Full Speed #2	1	11.1
Full Speed #3	1	11.1

15 Degrees	*Volts*	*Grams*
Half Speed #1	0.2	2.2
Half Speed #2	0.3	3.3
Half Speed #3	0.4	4.4
Full Speed #1	1.1	12.2
Full Speed #2	1.3	14.4
Full Speed #3	1.4	15.6

25 Degrees	*Volts*	*Grams*
Half Speed #1	0.4	4.4
Half Speed #2	0.8	8.9
Half Speed #3	0.9	10
Full Speed #1	1.8	20
Full Speed #2	1.9	21.1
Full Speed #3	1.9	21.1

Table F-4 Elliptical Wing Results

5 Degrees	*Volts*	*Grams*
Half Speed #1	0.1	1.1
Half Speed #2	0.2	2.2
Half Speed #3	0.2	2.2
Full Speed #1	1	11.1
Full Speed #2	1	11.1
Full Speed #3	1.1	12.2

15 Degrees	*Volts*	*Grams*
Half Speed #1	0.3	3.3
Half Speed #2	0.6	6.7
Half Speed #3	0.7	7.8
Full Speed #1	1.5	16.7
Full Speed #2	1.8	20
Full Speed #3	1.9	21.1

25 Degrees	*Volts*	*Grams*
Half Speed #1	0.3	3.3
Half Speed #2	0.6	6.7
Half Speed #3	0.8	8.9
Full Speed #1	1.6	17.8
Full Speed #2	1.9	21.1
Full Speed #3	1.8	20

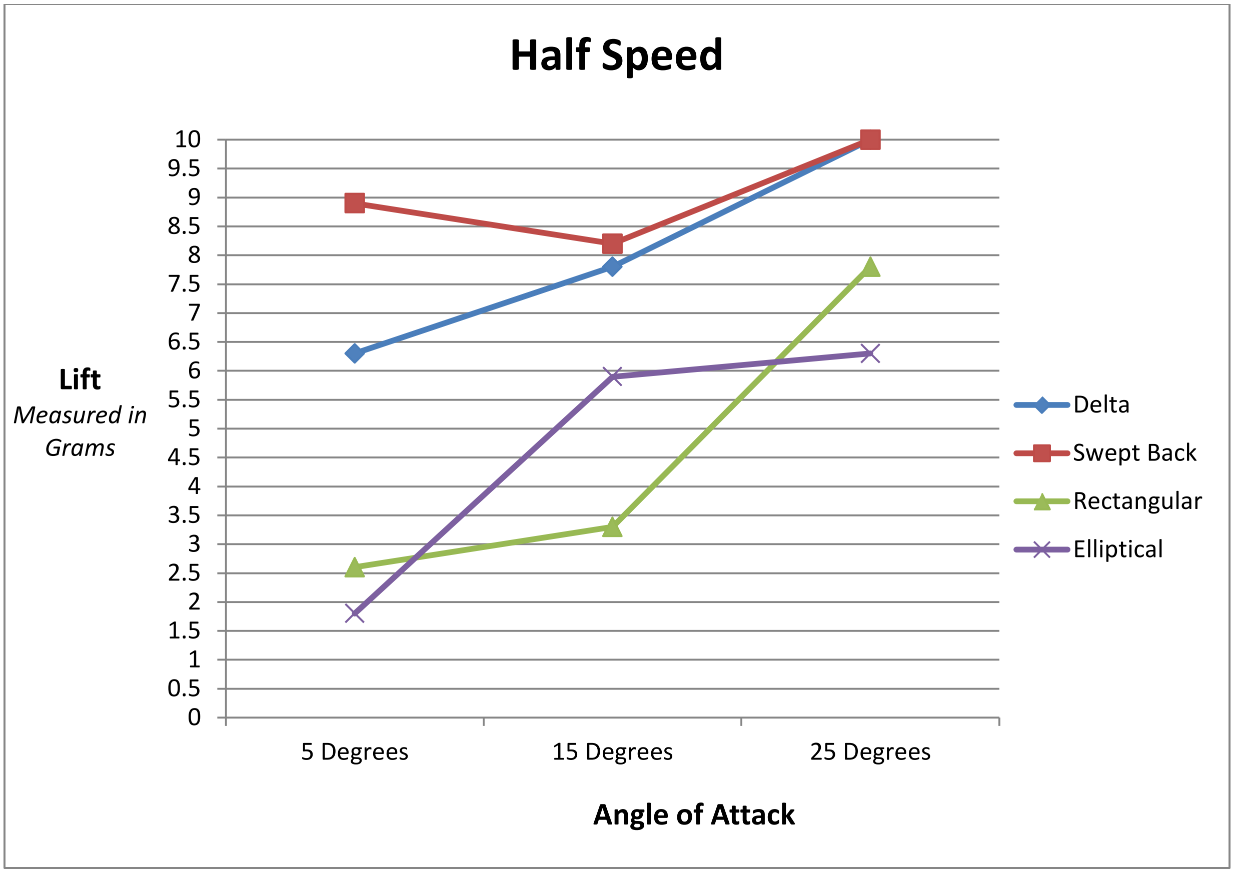

Figure F-30 Half Speed with 7 Inches Squared and Smoother Edges

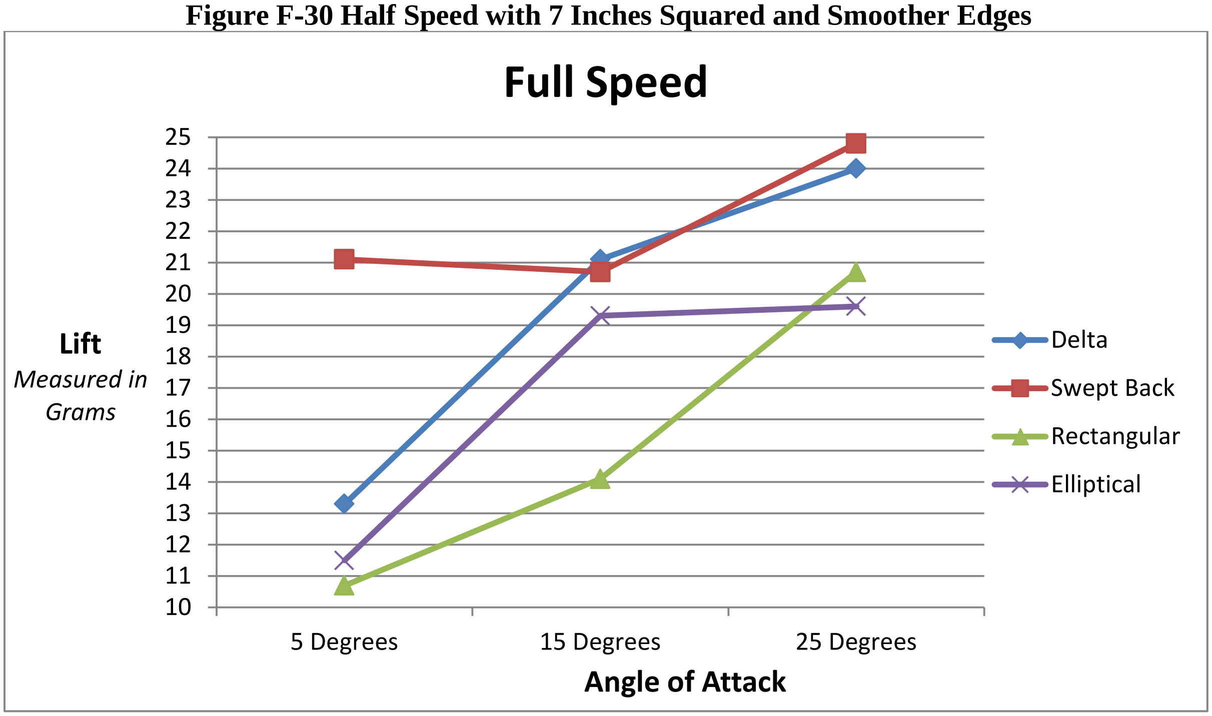

Figure F-31 Full Speed with 7 Inches Squared and Smoother Edges

F3.12 Discussion and Conclusion

The swept back shaped wing had the most lift at each angle of attack. The delta shaped wing had the second best lift at each angle of attack. The rectangular and elliptical shaped wings had the same lift at 5 degrees when you take average for full and half speed, but at 15 degrees the elliptical shaped wing had more lift and at 25 degrees the rectangular shaped wing had more lift.

My hypothesis was disproven. The elliptical shaped wing didn't have the most lift at each angle of attack. The delta and swept back shaped wings produced more lift than the elliptical shaped did. I believe my hypothesis was disproven because the swept back shaped wing creates little drag and the delta shaped wing creates even less drag and that there is a correlation between the drag and the lift. Also the different designs could have caused my hypothesis to be wrong.

F3.13 Acknowledgments

- *Mr. Noble*
- *Dr. Jones*
- *Dr. Saunders*
- *Dr. Sanders*
- *Mrs. Konechney*
- *Mr. Kowalski*
- *Mr. Baust*
- *Mr. Keith*
- *Dr. Leonard*
- *Mr. Eric*

F3.14 Next Steps

If I were to do a continuation of this project, I would use the same wings but change the camber (thickness) of the wings while finding their drag and lift.

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F4. Eggscellent Heat Transfer, Malik Bursey, Grade 10

F4.1 Introduction

Hello, my name is Malik Bursey and my project is over heat, heat transfer, and conduction between a stove, a pan and an omelet. My question is: how much heat is needed to cook a 3 eggs and cheese omelet using an electric stove in a 23.5 aluminum pan in under 20 minutes. I choose this project because I was interested in the process of how foods cook and what the perfect temperature to cook different foods. While doing my project I learn a lot about heat, heat transfer, and how it's used in cooking, specifically eggs. My project will show you why it is important to understand heat and heat transfer by showing how it is incorporated into cooking.

F4.2 Hypothesis

If you heat an electric stove burner to 200℉ and use a 23.5 cm non-stick aluminum skillet than you'll be able to fully cook, an omelet, using 3 eggs and cheese, in a 20 minute time period.

F4.3 Background Information

My project is based on heat and transfer due to conduction between a stove, a pan and a cheesy omelet. Heat in the term of conduction is a form of transferred energy that comes from the random motion of molecules and is felt as temperature is 75˚F than the heat produced by that object averages 75˚F. Heat goes by another name (thermal energy). The study of thermal which is thermal dynamics helps in explaining how heat occurs. To understand how heat occurs you must know that everything is made of matter and matter is made up of molecules in motion (kinetic energy) and as those molecules move the create heat; the faster they move the more heat they produce, resulting in an increase in temperature and vice versa. Heat transfers from warmer to colder matter, constantly in search of thermal equilibrium known as the second law of Thermodynamics.

Thermal equilibrium is when taking objects within a system reach the same temperature losing the ability to do work which is the force applied to an object over a distance which it travels by the result of the force.

Energy is the ability to do work, so in the term of thermal energy or heat when it is not able to do work, heat cannot be produced; meaning that when objects are in thermal equilibrium they cannot increase in heat unless affected by an outside force.

Heat transfer is when heat travels from one object to another, Heat transfer is most commonly occurs in the form of convection, conduction and radiation; however for the purpose of this project we will focus on conduction. Conduction is when heat travels from one touching object to another, for example: conduction between a stove and a pan (my experiment). The stove is heated by electricity running through coils of the stove while heating up the metal burners on top of the stove also note that this how an electric stove operates and not all stove stoves operate this way. The burners continue to heat up until they reach the desired set heat of the coils. Then heats the pan in place on the burner and one form of conduction occurs. The heat from the burner transfers to the pan and conduction at the same time the coils again began to heat the burner in order to keep the temperature of the burner equal to that of the coil, which would also increase the temperature of the pan until it is equal to that of the burner and coil and known as Zeroth Law.

Zeroth law of thermodynamics states that if two systems are separately found to be in thermal equilibrium with a third system, the first two systems are in thermal equilibrium with each other. Now, going back a little, you might ask the question, what is electricity? Electricity is the movement of electrons and electrons are negatively charged sub-atomic particles that make up an atom.

An atom is the smallest piece of an element containing all of the elements properties. The element is the simplest form of matter and everything is made of matter. Atoms are made up of three sub-atomic particles; protons, neutrons and electrons. Protons are positively charged and neutrons are uncharged, together they make the nucleus in electrons or the control center of the atom. Electrons orbit around the nucleus in electron orbitals. The outer most electrons orbital is called the valence electron. Atoms like to have their valence electron filled to eight or empty of electrons. As the electrons rapidly move around the nucleus the valence electrons can knock other valence electrons out of there orbit. When an atom loses an electron it seeks another to fill the vacancy. Electricity is produced as the electrons collide and transfer from atom to atom. Electricity is a force that provides light, heat, and sound. Different materials allow electricity to flow through it differently and the two types of conductors and insulators. Conductors such as copper and stove burners allow electrons to flow easily between atoms and 1-3 valence electrons. Insulators such as glass and wood make it difficult for electrons to flow between atoms; they have 5-8 valence electrons.

Now that you understand what thermal energy is and how it works you now need to know about the omelet but more importantly the egg. The egg is the oval shape objects laid by a female chicken which usually contains a developing embryo in them but don't worry because nearly all of the eggs in human market doesn't contain any embryo because they are fertilized. Eggs, the ones people eat contain a yolk surrounded by albumen. The yolk is the yellow or orange sack in the egg that would have been the food source for the developing embryos. The albumer is the clear liquid that surrounds it. When cooking eggs the temperature must reach at least 158°F for the eggs to cook, this is because at 158°F the eggs will denature which is when you destroy a protein natural three-dimensional structure which can be done by heat or chemically and at this

temperature eggs will cook but it would take about 20 minutes for it to fully cook the eggs and also it would still be unable to eat because diseases such as E Coli, which is a parasite are killed at the temperature of 160°F.

F4.4 Materials

- 23.5 cm non-stick pan
- Electric GE stove
- Infrared thermometer
- 3 eggs
- Cheese
- Timer
- Plate
- Spatula

F4.5 Procedures

1. Set stove top burner to 200℉, use infrared thermometer to make sure. 2. Place pan on burner record temperature of pan right before pouring eggs. 3. Grab timer and pre-mixed eggs, record temperature of mixed eggs, reset timer and pour in egg mixture (start timer as soon as mixture is completely in pan. 4. Record temperature of the omelet every minute it is cooking until 20 minutes pass (if omelet does not cook in 20 minutes stop cooking, record final temperature and throw away). 5. When eggs are firm and cooked, or at least appear cooked, sprinkle cheese on top and flip egg. 6. Remove omelet on to plate, stop timer, and record temperature of omelet and timer. 7. Check if omelet is completely done, record if it is or isn't. 8. Clean pan. 9. Repeat steps 1-8 but change the set temperature to 300℉, for trial 2, 400℉, for trial 3. 10. Record how much faster or slower each omelet cooked

Table F-5 Data/Results

		Temperature in degrees Fahrenheit		
		Trial 1	Trial 2	Trial 3
Time in minutes	1	108	104	112
	2	118	120	124
	3	121	129	135
	4	124	131	140
	5	125	135	141
	6	128	138	145
	7	129	140	146
	8	130	143	148
	9	131	145	149
	10	132	148	158
	11	133	150	161
	12	135	150	163
	13	136	152	
	14	137	155	
	15	139	157	
	16	140	159	
	17	140	161	
	18	140	162	
	19	140		
	20	140		

F4.6 Data Analysis

The table in Data/Results section is showing the average temperature of the omelets every minute till it was done. You should notice that trial 1 is the only trial that reaches 20 minutes.

This is because the time limit of the experiment was 20 minutes and the omelet did cook in it. In fact the omelet wouldn't cook at all be it stop heating up at 140̊F and it requires 158̊F to cook the eggs. The other two trial omelets did cook in the 20 minute period. This is because they were able to reach a temperature high than 158̊F with the 20 minutes, this allowed the eggs to cook and be done before time was up. The results of the experiments were not expect because I thought that the temperature of the burner had to be 158̊F to cook the eggs and that I only needed higher temperature to cook the eggs in the time limit. What I forgot to consider is that as the heat transfers, some of the heat is loss and not transfer on. Meaning if I set the burner to 200̊F than the heat of the omelet will be less than that of the burner because the heat is lost as it transfers from the burner to the pan then to the omelet.

F4.7 Conclusion

In conclusion, my question was how much heat is needed to cook a 3 egg and cheese omelet using an electric stove in a 23.5 cm non-stick aluminum pan within a 20 time period. My hypothesis was that it would require the burner to be at least 200̊F for the omelet to cook, I was wrong. The actual temperature required would be about 275̊F.I know this because at this temperature the burner would be able to transfer the required heat of 158̊F to the omelet and cook it in the 20 minute period. By using the information from this project you can understand the basics of heat, heat transfer and how it applies to cooking by showing that it takes certain heat to cook different food and that the heat transfer is never exact and should be taken into consideration when deciding what temperature you need to cook something. If I was to do this project again I would use more type of foods and see how they compare to each other. Also I would try using different types of heat transfer and see how they affect the cooking process. Thank you and I hope you like my project.

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F5. Belts in Robotic Drive Systems, Jasmin Sanford, Grade 11

F5.1 Introduction

The purpose of this project is to determine the most efficient synchronous belt model in which to use in building a robot to compete in the 2012-13 FIRST Robotics Competition. It came to competitors that in this year's robotics season, there will not be any chains allowed, so this experiment will help test for a better solution in using belts. The determining question for this project is “Which size rubber synchronous belts provided to in FIRST Robotics will provide more efficient performance by the elasticity?” The hypothesis formed was “If a maximum 20 lbs of weights are put on three 5mm synchronous belts, then the belts will show its stretching strength through the observation of the change in length, because of the weight increasing the force on the pulley to stay in its original form.” Independent variables discovered in this project were the models of the synchronous belts and weighing increments and dependent variables would be the force, length change, and widths of each belt.

F5.2 Background

In this project various belts were tested to become the selected belts in the robot building process. This project also has a reference to simple machines as the chassis that will be built, will resemble a pulley system. Once in the researching phase various relevant topics were looked into from drive systems, durability, reliability, friction, tension, simple machines. In a standard drive system design, the drive uses a gearbox-reduction motor with the power transmission as coupling which is all mounted on a motor frame. In an adjustable speed gear drive it is driven by an adjustable ggearbox drive transmission is via coupling and its mounted on a motor frame (www.engineeredtowork.com)

Gates Xtreme snowmobile belt, built for aggressive trail running features DuPoint Kevlar materials to maximize durability, performance, and service life. For example, with Kevlar tensile, belt fatigue, stretch and growth are minimized. It can handle loads up to 160 hp and over 9,000 rpm. The belt's resistance to temperature extremes provides excellent overall performance in operating ranges from -30°F to 230°F. Frictional resistance to the relative motion of two solid objects is usually proportional to the force which presses the surfaces together as well as the roughness of the surfaces. Kinetic force is when an object is in motion, and static is when the object is at rest and more force is taken to move it according to Wikipedia. In some belts there is excessive slippage if there aren't any teeth on it. When two pulley systems are present, the belt drives the pulley in the same direction or the belt may be crossed, so that the direction of the shafts are opposite.

Timing belts use the least tension of all and most efficient among others. There is also a helical offset forming a chevron pattern and causes teeth to engage progressively. They are often used in lieu of chains or gears, so there is less noise and a lubrication bath is not necessary. Camshafts of automobiles, miniature timing systems, and stepper motors often utilize these belts. Timing belts need the least tension of all belts, and are among the most efficient. They can bear up to 200 hp (150 kW) at speeds of 16,000 ft/min. Timing belts with a helical offset tooth design are available. The helical offset tooth design forms a chevron pattern and causes the teeth to engage progressively. The chevron pattern design is self-aligning. The chevron pattern design does not make the noise that some timing belts make at certain speeds, and is more efficient at transferring power (up to 98%). Disadvantages include a relatively high purchase cost, the need for specially fabricated toothed pulleys, less protection from overloading and jamming, and the

lack of clutch action (Wikipedia).
http://www.ckit.co.za/secure/conveyor/troughed/belt_tension/belt_tension_factors.htm

A simple machine is an elementary device that has a specific movement (often called a mechanism), which can be combined with other devices and movements to form a machine. Thus simple machines are considered to be the "building blocks" of more complicated machines. A pulley is a wheel on an axle that is designed to support movement of a cable or belt along its circumference. Pulleys are used in a variety of ways to lift loads, apply forces, and to transmit power. A pulley is also called a sheave or drums and may have a groove between two flanges around its circumference. The drive element of a pulley system can be a rope, cable, belt, or chain that runs over the pulley inside the groove. Hero of Alexandria identified the pulley as one of six simple machines used to lift weights. Pulleys are assembled to form a block and tackle in order to provide mechanical advantage to apply large forces. Pulleys are also assembled as part of belt and chain drives in order to transmit power from one rotating shaft to another (Wikipedia). Power transmitted between a belt and a pulley is expressed as the product of difference of tension and belt velocity: * P=(T_1-T_2)v where, T1 and T2 are tensions in the tight side and slack side of the belt respectively. They are related as: * \frac{T_1}{T_2} = e^{\mu\alpha} where, μ is the coefficient of friction, and α is the angle subtended by contact surface at the centre of the pulley. Belt drive, moreover, is simple, inexpensive, and does not require axially aligned shafts. It helps protect the machinery from overload and jam, and damps and isolates noise and vibration. Load fluctuations are shock-absorbed (cushioned). They need no lubrication and minimal maintenance. They have high efficiency (90-98%, usually 95%), high tolerance for misalignment, and are inexpensive if the shafts are far apart. Clutch action is activated by releasing belt tension. Different speeds can be obtained by step or tapered pulleys.

The angular-velocity ratio may not be constant or equal to that of the pulley diameters, due to slip and stretch. However, this problem has been largely solved by the use of toothed belts. Temperatures ranges from −31 °F (−35 °C) to 185 °F (85 °C). Adjustment of center distance or addition of an idler pulley is crucial to compensate for wear and stretch. The modulus of elasticity is calculated by dividing the stress by the strain:

Modulus of elasticity
Where M is the modulus of elasticity (ISO 9856)
F is the force (N)
εelast is the elastic elongation at the end of the specified number of cycles in N/mm
Tension force
Where T is the tension force
λ is the modulus of elasticity
A is the cross-sectional area
x is the extension
l is the length (m)
MINIMUM BELT TENSION FOR BELT SAG LIMITATION (top side, loaded)
Minimum belt tension top run loaded
Where g is gravity (9,81 m/s²)
m'Li is the mass of the conveyed material, uniformly distributed across a section of the conveyor (kg/m)
m'G is the length related mass of the conveyor belt (kg/m)
IRo is the idler spacing in top run (m)

hrel is the maximum belt sag related to the spacing between the carry idlers (%)
MINIMUM BELT TENSION FOR BELT SAG LIMITATION (bottom side, unloaded)
Minimum belt tension of return run
Where g is the gravity (9,81 m/s²)
m'Gis the length related mass of the conveyor belt (kg/m)
IRu is the idler spacing in bottom run (m)
hrel is the maximum belt sag related to the spcing between the carry idlers (%)
-http://www.conveyorbeltguide.com/Equations.html#ModulusOfElasticity

F5.3 Materials

1. 3 rubber synchronous belts (5MR900, 5MR1000, & 12705M15)
2. 2 sprockets (fully finished with flanges)(P16-5M-09AL)
3. 1 C-channel rod
4. Calculator
5. Hollow metal rod
6. 6 barbell weights (4 - 5lbs & 2 - 10lbs)
7. Vierner's LabQuest
8. Vierner's Dual-Range Force Sensor
9. 12 Zip ties
10. Measuring tape
11. Masking tape
12. Table vice grip

F5.4 Procedures

1. Build the rig (channel and sprocket is mounted together)
2. Place vertically in a table vice grip
3. Measure circumference of the belts and record them before placing 1 on the other sprocket fixed with 2 zip ties and the mounted sprocket
4. Hook the force sensor on to the ties
5. Insert the rod through the hole
6. Add a (5 lbs) barbell weight on either side of the rod
7. Record the force through the Labquest and also the change in length
8. Replace the weights with (10 lbs) on either side of the rod
9. Record the force through the Labquest and also the change in length
10. Add the weights for (15 lbs) on either side of the rod
11. Record the force through the Labquest and also the change in length
12. Add the weights for (20 lbs) on either side of the rod
13. Record the force through the Labquest and also the change in length
14. Repeat procedures (6-13) for two more trials and record force and length results
15. Complete procedures (4-14) again for the other two modeled belts in the experiements
16. Record the differences of each belt and graph.

F5.5 Discussion

In the experimentation of this project elasticity of three Gates Power Grip Synchronous belts were tested. Several weights were equally placed to balance the weight and stretch the belts on the rig. It takes help from physics and an engineering background to complete this project

because of the variables used. Elasticity requires a physics equation and the engineering aspect comes from knowledge of pulleys, simple machines, sensors, and the Lab Quest usage. The four main factors needed to find the modulus of elasticity are; force, circumference (original length), original cross-sectional area, and amount by which length of object changes. Charts from the pervious pages shows the results from the three trials completed. Based on recorded data on average the 1150MR-09 held more weight and stretched the least. While conducting this experiment partial data was not useful due to improper set up of the rig and the sensor.

F5.6 Conclusion

In this project the belts have stretched at a slow rate but enough to find an average. The hypothesis; "If a maximum 20 lbs of weights are put on three 5mm synchronous belts, then the belts will show its stretching strength through the observation of the change in length, because of the weight increasing the force on the pulley to stay in its original form." was proven correct.

12705M15 Rubber Synchronous Belt
ModE = (51.39)(166.5)/(53)(54.54) = 2.96Nm^2
5MR900-15 Rubber Synchronous Belt
ModE = (51.89)(113.1)/(36)(36.68) = 4.44Nm^2
5MR1150-09 Rubber Synchronous Belt
ModE = (51.56)(152.37)/(48 ½)(49.16) = 3.30Nm^2

F5.7 Works Cited

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c.http://www.engineered-to-work.com/en/Products/Shredding+technology/X_Ripper/Types+of+drive+systems.html
d.www.ckit.co.za/secure/conveyor/troughed/belt_tension/belt_tension_factors.htm
e. Gates Corporation.http://www.gates.com/brochure.cfm?brochure=977&location_id=540
f.www.conveyorbeltguide.com/Equations.html#ModulusOfElasticity

F6. Titration, Mitchell Cowan, Grade 11

F6.1 Purpose

In this project, sulfuric acid (H_2SO_4) and sodium hydroxide (NaOH) will be combined into an aqueous solution in an analytical process called titration. The purpose is to determine whether or not the mixture of sulfuric acid and sodium hydroxide will have a chemical reaction and neutralize each other. Additionally, the First derivative method of calculus will be used to determine the equivalents point, and once solved, create a approximated derivative function for the strong acid and strong base titration.

F6.2 Question

Will the mixture of Sulfuric Acid, which is a strong acid with Sodium Hydroxide, a strong base cause a reaction that would result in neutralization?

Sulfuric acid is a very strong chemical that is corrosive. Corrosive means it can cause severe burns and tissue damage when it comes into contact with the skin or mucous membranes (health.nytimes.com). Sulfuric acid has many harmful effects, and can makes you sick, swell

your throat, burn your eyes, and deflect your vision, vomiting, and many other problems that could lead to death.

Pure sulfuric acid is as thick and syrupy liquid, which is stable and nonvolatile at room temperature. Reactions of concentrated sulfuric acid solutions are very exothermic – a lot heat is generated. In fact, significant heat is still generated even after diluting a sulfuric solution with water. Approximately 70 percent of sulfuric acid production is used in the manufacture of chemical fertilizers that contain phosphorus.

Sodium Hydroxide is also a corrosive chemical, and can cause the same health problems as sulfuric acid. Sodium Hydroxide is also commonly known as lye and is used to remove fats and grease from clogged drains. Sodium hydroxide is also used in the conversion of fat into soap.

F6.3 Hypothesis

If an unknown amount of sodium hydroxide, a strong base is added to a known amount of sulfuric acid, a strong acid then the sulfuric acid and sodium hydroxide will eventually reach an equivalence point or become neutral because acid and base chemicals become neutral when the number of equivalents of acid are equal to the number of equivalents of base.

F6.4 Background Discussion

The history of the acids and bases started with the theory of two men, a Danish chemist by the name of Johannes Nicolas Bronsted, and a English chemist named Thomas Martin Lowry in 1923. In their theory, it states that "any substance that can transfer(donate) a proton to any other substance is considered an acid. And the compound that accepts the proton is a base. Today this is called the Bronsted-Lowry theory.

Sodium hydroxide is a strong base and can receive hydronium ions since a base is negatively charged, and by the rule of neutralization reaction, chemical substances (reactants) is converted into another (products). It involves making and breaking chemical bonds and the rearrangement of atoms (chemistryexplained.com). This means that the sodium hydroxide will strip the sulfuric acid of its hydronium ions, which will makes the acid change into a basic solution, and a basic solution means less hydronium ionic concentration , and also means that the sodium hydroxide neutralized the sulfuric acid compound. If sodium hydroxide is combined with sulfuric acid then sulfuric acid with lose it acidic characteristic, because sulfuric acid is reacting with sodium hydroxide, it will change the chemical property in which sulfuric acid will have a changed property. Calculating the titration curve will be done using the pH meter using the math of the rate of change of a function. "At the beginning, the solution has a low pH and climbs as the strong base is added. As the solution nears the point where all of the H+ are neutralized, the pH rises sharply and then levels out again as the solution becomes more basic as more OH- ions are added.(http://chemistry.about.com)"

Acid; A chemical with positive hydrogen ions that donates protons to another substance, between ph 0 to 7.

Base; A chemical with negative hydroxide ions and can accept hydrogen ions(protons), has a ph between 8 to 14.

Titration; The process of adding an acid to a base till it reaches the equivalents point. Titration is used to find the concentration of a chemical, this gives the chemical "its name" and clarifying what it is. The origin of volumetric analysis dates to around the 18th century when French scientist Francois Henri first developed the burette. However, it was because of Karl

Mohr that titration became known worldwide. Mohr popularized the methods and procedure of titration to all corners of the world through his textbook that was published in 1855.(ehow.com). Titration fundamentally has two distinct meanings in both the scientific and medical spheres. In science it is a method used in the laboratory to analyze samples while in medicine titration can refer to the process of reducing a patient's dose gradually until they are healed. In the scientific world, and particularly in chemistry it is the process of finding a concentration of certain reactants in solutions. Because of this functionality, titration is also known as volumetric analysis, due to a heavy reliance on the measurement of volume and concentration. (content4reprint.com)

Neutralization; The reaction between an acid and a base to make salt and water. Neutralizations began with Svante Arrhenius (1859-1927) in 1884 and Johannes Brønsted (1879-1947) and Thomas Lowry (1874-1936) in 1923. These people first articulated the chemical properties of acids and bases and how the two substances react in water to form salts. Brønsted and Lowry defined acids as **hydrogen proton** donors and bases as hydrogen proton acceptors. The Brønsted-Lowry definition is best understood and most used by chemistry students. Gilbert Lewis's (1875-1946) definition of acids and bases, also published in 1923, is useful when substances do not contain or receive hydrogen. (http://science.jrank.org)

End-point; Where the indicator changes color in the titration.

Equivalent Point; There are equal moles of base to acid

Sulfuric Acid(H_2SO_4); Strong acid, high number of hydrogen ion concentration, corrosive. Used in the steel-making industry, and removes rust. It was prepared by Johann Van Helmont (c.1600) by destructive distillation of green vitriol (ferrous sulfate) and by burning sulfur (http://www.infoplease.com)

Sodium Hydroxide (NaOH); Strong base, negatively charge hydroxide ions, corrosive. Used to make paper, soup, drain cleaners, used to neutralize acids. Sodium Hydroxide was discovered by Sir Humphrey Davy while in England in the year 1807.

Phenolphthalein; Acid-base titration indicator, colorless in acidic solutions, red in basic solutions.

pH; Mathematical equation -log[H30+] Know as molarity, the power of hydrogen, negative logarithmic scale.

Titration Curve; A titration curve is a curve in the plane whose *x*-coordinate is the volume of titrant added since the beginning of the titration, and whose *y*-coordinate is the concentration of the analytic at the corresponding stage of the titration (in an acid-base titration, the *y*-coordinate is usually the pH of the solution).(wikipedia.org)

F6.5 Materials

- Burette Kit
- pH meter
- Indicator (phenolphthalein)
- Calculator TI-83
- Reading card
- Sodium Hydroxide
- Sulfuric Acid
- Gloves(rubber)
- Goggles
- Distilled water

- Pipette
- Erlenmeyer Flask(125mL)
- Waste beaker
- Sheet of white paper
- Magnetic Stirrer
- Small Funnel
- pH 4 buffer solution
- pH 7 solution
- Kim-wipe
- Lab coat

F6.6 Procedure Test 1 w/ Phenolphthalein (Sulfuric Acid)

Basic procedure is to combine sulfuric acid and sodium hydroxide using (neutralization) titration, and use the First derivative method to calculate the equivalents point.

Step One: Clean the burette with distilled water, then with rinse with sodium hydroxide, then setup the burette on a level table and place the burette where the 0 mark is at eye level.

Step Two: Fill the burette with sodium hydroxide till it reaches the top, Check for air bubbles, then release the sodium hydroxide till it's at the zero mark, wait for one minute then read the initial volume and record it. The sodium hydroxide does not have to be exactly at zero.

Step Three: Rinse the Erlenmeyer flask with cold distilled water then fill the bottom of the Erlenmeyer flask with sulfuric acid to the 50mL mark, then add cold water to dilute the sulfuric acid till it's to the 75mL, then add 4 drops phenolphthalein.

Step Four: Begin a rough experiment trail to get a rough approximate idea of the endpoint of reaction. Add the sodium hydroxide from the burette into the Erlenmeyer flask quickly. Observe to see when the pink color in the sulfuric acid changes and stays, this is the approximate reading. Knowing that a rough trail has been experimented, begin to titrate, in a drop wise manner, add the sodium hydroxide to the sulfuric acid, swirl for every drop, once the sulfuric acid solution turns a pale pink and keeps that color for 30 seconds, the chemical has been neutralized and also has reached its endpoint. If the sulfuric acid turns a dark pink, that means its pasted its endpoint and went too far. DO NOT PASS THE ENDPOINT! This means to much base had been added to the sulfuric acid, if the sulfuric acid is not a pale color, that means the sulfuric acid is undershot and is not completely neutralized. Repeat trials 3 times and average the tested recordings, and each trail test more precisely.

Step five: Analyze the recordings, write how many mL are left in the burette to neutralize the sulfuric acid. Then calculate the equivalence point using the following equation:

$$N_a \text{ x } V_a = N_b \text{ x } V_b$$

Where, N_a is the concentration of the acid, V_a is the volume of the acid, N_b is the concentration of the base, and V_b is the volume of the base.

F6.7 Procedures with pH Meter (Sulfuric Acid)

In this test the titration curve will be calculated using and texted using the First and Second derivative method. A pH meter will be used to plot the pH changes with respect to the volume added.

Step One: Fill the burette with the titrate, check for air bubbles and set the titrate to zero.

Step Two: Calibrate the pH meter with the buffer solutions, then in the sodium hydroxide.

Step Three: Drop the electrode into the sulfuric acid then begin the titration experiment, read the pH meter and plot each change to the pH with respect to the volume added, create a curve to the plots. When a spike in the pH meter goes above 7 and start raising quickly, the acid has been neutralized. Analyze the titration curve, and where the curve sharply curves, pass pH 7 is the equivalents point.

Step Four: Once the points has been plotted from the experiment, use the first and second derivate and approximate the equivalent point then compare to the eyeball reading, then to create a function from the derivative form, Then use C++ to create a input function to calculate output results for the titration function approximations, and Mat Lab to display a titration graph.

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History of acids and bases

APPENDIX G
Overview of Academic Year 2013-2014
Thurgood Marshall High School Math and Science Club Activities

The Thurgood Marshall Math and Science Club meets every Wednesday at 4:00-6:00 PM in Room 1114. The format for every meeting is similar. Prior to Wednesday's Math and Science Club meetings the officers and captains hold a planning meeting.

G1. Weekly Planning Meetings

Planning meetings are held on Mondays, or the first day of the school week, and they are held to delegate responsibilities and give reports on the upcoming and past events of the club. The club officers and focus team captains were required to attend and manage these meetings. The main purpose of these meetings was to make an agenda for the next club meeting, receive updates from each focus team, and air any "dirty laundry" we may have. During these meetings this year, we discussed things like events held at our school sponsored by us, for example, the installation of club officers, the awards ceremony, 8th Grade visitors, and the state robotics competition.

G2. Weekly Club Meetings:

The focus of the meetings is based on the activities of the time period. From September through December, most meetings are about the Science Fair with work sessions to help students complete a successful project and periodically presenting their progress and projects to the other members. We had several Mentors from the WPAFB such as: 2nd lieutenant Joe Svejkosky. We also had some other mentors such as the three leading officers and Mr. Don Sanders. If we have any new, conditional members, we have introductions and a few activities that allow us to meet and greet. After science fair, which is around January, we try to focus our club meetings on our focus teams and the activities they have coming up. Between the months of January and March, our club focuses on Robotics for the rest of the school year, as it gets warmer outside, our club focuses on Flight team activities.

Our club meeting usually work like this: the president begins each meeting with a call to order. Next, the president continues on with new business and announcements and has team captains come forth with any reports. Students then move on to the focus of the meeting which can be a keynote speaker, debrief from the president, Engineering of the Month activity, or a fun science lab. Key speakers provide information of math and science and real life applications. In the 2013-2014 school years we have had a few speakers ranging in various STEM fields. The guest speakers we acquired throughout the school year are Khayln Miller, Lieutenant Joe Svejkosky, and Mr. Mike Zwyien. We also have had a few different activities such as the RC Car Races, the Tallest Structure Competition, Flight Simulation Competition, Jeopardy, Wind Tunnel activity, and Helicopter Simulation Competition.

Meeting Minutes for August 21, 2013: Call to Order at 4:02 p.m. We did an Ice Breaker to get to know everyone and to meet the new members. Kadijah did a Prezi presentation to tell about the club, membership, excused absents, unexcused absents and focus team. Jasmin talked about AQT and Tarrick talked about flight. The flight team is about flying, building airplanes and going to competition. If a member wants to start a new focus team, the member can tell Kadijah about the idea. Every club member has to be on a focus team. Activity: Students will be building a tall structure out of spaghetti noodles and marshmallow trying to see which group has

the high structure and will win a prize. There will be 3 groups of 3 members and 1 group of 4 members. Winners were Khayln, Shepria, and JaVonn. The winners won a flash drive 4GB. Snacks were passed out and we adjourned at 5:20 p.m.

Meeting minutes for August 28, 2013: The announcements were as followed: Members need to give us their contact information on the Math & Science club website www.tmhsmathandscienceclub.weebly.com, if a member brings a new member to 3 consecutive Math & Science Club meetings they get a reward, and Tarrick White passed out Academy of Model Aeronautics Enrollment forms to members to bring back filled out and signed by their parent or guardian so they can be on flight team. The activity was as follows: We had a science fair discussion. Kadijah Taylor put together a Prezi informing members had to do a science fair project, the dates and deadlines for science fair which are: Sep. 18th - Research Plan, Oct. 2nd - First Draft of Research Report, Oct. 30th - Final Draft, Nov. 20th - Display Board and Abstract, Dec. 4th – Assessment, Dec. 12th - Science Fair. The Prezi also included: Research Plan – Proposal for a science fair project and consist of a question, hypothesis, materials, procedure, background research, and works cited. Final Report – Title Page, table of contents, introduction, abstract, background research, hypothesis, methods, procedure, materials, results, discussion, conclusion, what you would do next, and works cited. Abstract – 250 word summary of your project. There was a video breaking down the scientific method with a rap. After we were finished with the Prezi we had an engaging conversation with the members about what interest them. Everyone was asked to think about that thing that interested them and try and form a question about it and bring it back to next week's meeting. We also told the members how they will have help for their science project from officers and mentors if they ever need it. Tarrick White conducted a competition for the flight simulators. His rubric was focusing on the visuals, landings, flight, and take off. Mitchell Cowan, Kadijah Taylor, and Tarrick White were the three judges for the three teams. They judged each area on the rubric from 1 to 10, 10 being the best, and added everyone in a group's score for the total. Tarrick showed a tutorial of how to fly the simulator and everyone got a 1 minute practice round before they did their two minute flight that was evaluated by the judges. The purpose of this activity is to see who is ready to fly the real planes and helicopters and who needs practice. The winning team was: Khayln Miller, Shepria Pointer, JaVonn Honaker, and Tarrick White. They won a pack of skittles. We passed out snacks and adjourned at 5:48 p.m.

Meeting Minutes for September 4, 2013: Kadijah Taylor called the meeting to order at 4:07 p.m. The announcements were as followed: Research plans are due September 18th and you can turn your flight applications in to Tarrick White if it's filled out. For the science fair discussion some of members elaborated with club on their questions they could use for a science project. There questions are as follows: Paul Lynch: Can you change your car engine to a steam engine? Kadijah Taylor: Linear vs. logarithmic change? Khayln Miller: Difference between highly cambered and low cambered airfoil. Da'quan Wood: How do you separate salt from water? Thomas James: Question on baking soda, baking powder, and vinegar. Kadijah Taylor passed out research plan preparation sheets to the club members. Khayln Miller's presentation was on what he learned and did at Wright Patterson Air Force Base this summer. He learned about basic physics, basic thermodynamics, control surfaces, boundary layers, propulsion, and much more. He started making a laminar flow wind tunnel and has built the key components which are the diffuser and the contraction. He enjoyed his experience there on base and hopes to return next summer. We passed out snacks and adjourned at 5:30 p.m.

Meeting minutes for September 11, 2013: Kadijah Taylor called the meeting to order at 4:01 p.m. The announcements were as followed: Research plans are due September 18th, members can turn their flight applications in to Tarrick White, and we still offer a prize to members who bring someone to three consecutive meetings. We discussed about motion because it was relevant to the activity. We went over Newton's three laws of motion: Law of Inertia, Force = mass x acceleration, and for every action, there is an equal or opposite reaction. The activity was a race tournament between two members at a time racing RC Cars. If they won, they moved on to the winner's bracket, and if they lost, they moved to the loser's bracket. Tarrick White gave a tutorial of how to drive the cars. Mitchell Cowan came in first place for the winner's bracket and Tarrick White came in first place for the loser's bracket. We passed out snacks and adjourned at 5:52 p.m.

Meeting minutes for September 18, 2013: Kadijah Taylor called the meeting to order at 4:03 p.m. The announcements were as followed: Research plans were due today September 18th, members can turn their flight applications in to Tarrick White, sign up for "Reminder 101" text message alerts from Math & Science Club, just text 345msclub to (567) 302-2727, and SAIC interns and Khayln Miller will be presenting their project to the DPS Superintendent, Mr. Mike Zywien, and other special guest. For the jeopardy activity each team had a spokesperson that picked categories and answered questions after the team deliberated with them. There were five categories: math, science, social studies, job outlook, and miscellaneous. Each category had 5 questions worth: 100, 200, 300, 400, and 500 points. Team one won with 3000 points and team two had 1900 points. We passed out snacks and adjourned at 5:41 p.m.

Meeting Minutes for October 2, 2013: Kadijah Taylor called the meeting to order at 4:00 p.m. The announcements were as followed: Research plans are due, flight applications are due today, there is a science fair workshop and it is this Saturday, October 5th from 10 a.m. to 12 p.m. and all club members are required to be there, the Robotics team won 2nd place at the Ohio FIRST Robotics State Competition, and ACT prep is tomorrow, October 3rd, in room 1114 from 4 p.m. to 7 p.m. For the wind tunnel activity, members got this background information: Wind tunnels are used to test models of proposed aircrafts; lift is the force that directly opposes the weight of an airplane and holds the airplane in the air, Bernoulli's Principle works on the idea that as a wing passes through the air, it's shape makes the air travel more over the top of the wing than beneath it. This creates a higher pressure beneath the wing than above it. The pressure difference causes the wing to push upwards and lift is created. The purpose of the activity was for members to make a design they felt would create a lot of lift and learn about what aerodynamic factors affect the lift of a design. Each member got a 5x5 piece of Styrofoam board and time to make a design so they could see how much lift it creates. Malik Bursey had the highest lift that measured 5 volts on the wind tunnel. He received a prize because he had the most lift. The factors they learned that effects lift are: Large surface area, smooth edges, and wing geometry. We passed out snacks and showed our State Finalist banner and Trophy from the Robotics State Competition. Also Mrs. Glenda announced that if you want to go on the field trip October 18th, you need to attend the science fair workshop this Saturday, October 5th. We adjourned at 5:51 p.m.

Meeting minutes for October 9, 2013: Kadijah Taylor called the meeting to order at 4:02 p.m. Khayln Miller did roll call afterwards. The announcements were as followed: Research plans are due, flight field trip is October 18th, ACT/OGT prep is tomorrow, October 10th, in room 1114 from 4 p.m. to 7 p.m. and the subject is math, and Mitchell Cowan invited 4 new people to join the robotics team and gave them a robotics schedule. The activity was a science

fair work shop which was led by Mr. Noble. He started off by reminding the club members that the math and science club is sponsored and that the freshmen need to make a science fair project and defend it to stay in the club. Next he asked all the members for the following: What is your research topic? What is the research question or problem? What is the hypothesis? He ended by telling the club members sponsors won't pay for math and science club activities if the members don't come through with what they have to do. We passed out snacks and adjourned at 5:21 p.m.

Meeting Minutes for October 16, 2013: Kadijah Taylor called the meeting to order at 3:59 p.m. The announcements were as followed: ACT prep class next Thursday, October 24th, from 4 to 6 p.m., Flight meeting next Tuesday, October 22nd, from 4 to 5 p.m., and Robotics is next Tuesday, October 22nd, from 5 to 6 p.m. The activity was a science fair work shop. Mr. Noble showed us a video about Jack Andraka who is a fifteen year old freshman in high school. He developed a paper sensor that could detect pancreatic, ovarian and lung cancer in five minutes for as little as 3 cents. He conducted his research at John Hopkins University. This research could change the face of cancer and promote early detection. We had a guest, Lieutenant Svejkosky, who came in and donated to the math and science club a robotic arm. The arm can be programmed to pick up markers and draw and play the piano because it servo motors and five degrees of freedom. Kadijah finished off the science fair workshop by asking a few members what their science fair problem was. We passed out snacks and adjourned at 5:36 p.m.

Meeting minutes for October 23, 2013: Kadijah Taylor called the meeting to order at 4:05 p.m. The announcements were as followed: ACT prep class is tomorrow, October 24th, from 4 to 6 pm, talked about flight field trip, flight meeting from 4 to 5 pm and robotics meeting from 5 to 6 pm, next Tuesday, October 29th. The science fair update was led by Mr. Noble and he focused on the seniors because they need to lead the rest of the club. The following is the update for the senior's science fair project: JaVonn Honaker needs to have an updated version of her research plan and her topic is Soybean plants. Mitchell Cowan has sent in his updated research report and his topic is Aerodynamic Programming. Kadijah Taylor has sent in multiple research reports and her topic is Light Bulbs. Shepria Pointer sent in her research report and needs to narrow down her topic and her topic is Reverse Engineering. Mr. Noble stated the people who didn't finish science projects never can finish the 6 week build season in robotics. This is because it shows who is dedicated and who isn't. Kadijah Taylor showed her PowerPoint for recruitment in the Math and Science Club. It consisted of: What is the Math and Science Club, what we do, membership requirements, activities, Flight, Robotics, AQT, ACT/OGT Prep Class, and the website link (www.tmhsmathandscienceclub.weebly.com). We asked the members if they weren't in the club would they join based off of the presentation, the feedback is as follows: Thomas James said he would join, Te'Andre Martin wouldn't, and Kyle Knight would. Aaryn Evans suggested we add more pictures of club members and add a caption of their name so other students could see people they know are in it. Some different venues suggested for showing the presentation were during 3rd period math and science classes, have an assembly with freshman and sophomores and show it, and at a rush week for the Math and Science Club after science fair. The activity was RC Helicopter Simulators which was led by Tarrick White. He showed a presentation on how to control the helicopters and explained what rudders, elevators, and ailerons were. They were to fly helicopters on the simulators and were individually graded as a group on hovering, flight, and landing, the group with the highest score won. They had to hover for at least 10 seconds at a steady altitude. Each team got 5 minutes to practice. Team 2 won, they consisted of Khayln Miller, Thomas James, and Te'Andre Martin. We passed out snacks and adjourned at 5:53 p.m.

Meeting Minutes for October 30, 2013: Kadijah Taylor called the meeting to order at 4:00 p.m. and Khayln Miller did roll call. The announcements were as followed: ACT/OGT prep class is tomorrow, October 31, from 4 to 6 pm, flight meeting, November 5, from 4 to 5 pm, and robotics training camp starts November 12, from 4 to 6 pm. Malik Bursey and Tyrone Berry are to bring back the answer to next week's math problem and Richard Conn and Kyle Knight are to bring back the answer to next week's science problem. We couldn't do our activity outside because of the rain so we worked on our science fair projects. Quran Lee still hasn't shown a research plan or report to the club. Paul Lynch hasn't either. Tyrone Berry needs an update on his. Kyle Knight needs an update on his research report. The club went into Mr. Ciprian's room to work on the computers. We passed out snacks and adjourned at 5:58 p.m.

Meeting minutes for February 26, 2014: Kadijah Taylor called the meeting to order at 4:08 p.m. The announcements were as followed: We leave for the St. Louis robotics competition trip on March 12th. For the science fair workshop we went over student's judging sheets from district science fair and gave them the following feedback: Sade Foster needs to talk to her project better and keep it simple. Malik Bursey needs to get a little more research on basic heat transfer. Khayln Miller needs to do his testing for the elliptical wing over. Mitchell Cowan needs to slow down when he talks to his project. Kadijah Taylor needs to explain more on her topic. Tyrone Berry needs to reset one of the guitar strings and not look at his board so much. Tarrick White needs to do a little more research and to put more in his log book. Shepria Pointer needs to calculate the rate of heat loss and change the structure of her project around. We passed out snacks and adjourned at 5:58 p.m.

Meeting minutes for March 5, 2014: Kadijah Taylor called the meeting to order at 4:00 p.m. The chairmen award's video is 2 minutes and 55 seconds long. We were suggested to cover the correct content and change the end of the video's credits. Kadijah Taylor, Mitchell Cowan, and Khayln Miller practiced the optimist presentation they have to present tomorrow, March 6th, 2014. We adjourned at 6:30 p.m.

Meeting minutes for March 19, 2014: Kadijah Taylor called the meeting to order at 4:15 p.m. The announcements were as follows: Kadijah Taylor has applications to be an officer in the Math and Science Club next year, Team 2665 is ranked 15 out of 55 teams in the state of Ohio, and the Ohio State robotics Competition will be held at Thurgood Marshall this year!!! The presentations went in the following order: Malik Bursey: Electric vs Induction, Mitchell Cowan: Induced Drag Coefficient, Tarrick White: Solar Powered R/C Car, Tyrone Berry: Musical Sounds, Kadijah Taylor: Heat vs Illumience: CFL vs LED, Khayln Miller: Lift to Drag Ratio. We adjourned at 6:26 p.m.

Meeting Minutes for April 16, 2014: Kadijah Taylor called the meeting to order at 4:01 p.m. The announcements were as follows: World Championships are next week (we are in the Galileo division), State Competition is May 17th and State Science Fair is May 10th. For the activity we had a discussion for new members that consisted of the following: 1) Name, D.O.B, & Grade 2) Hobbies 3) Where do you see yourself in five years? 4) Why'd you come to the math and science club 5) what would you like to do in the club? 6) What would you like to get out of the club? 7) Tell us your story. The first student information is as follows: 1) Aaryn Evans, 03/29/1998, 10th grade 2) Basketball, reading, listening to music 3) "I don't know for sure" 4) "Tarrick invited me" 5) Read math and science books 6) Opportunities such as internships and experiences such as traveling. The second students information is as follows: 1) Jalla Groves, 11/27/1996, 11th grade 2)Eating, sleeping, math, watching TV 3) Registered nurse or obstetrician 4) "My mom said get involved with an extra activity that'll help for college" 5)Decorate and help

make bumpers for the robotics team 6) Learn more science and tutoring. We adjourned at 5:54 p.m.

The Math and Science Problems and Answers the students completed during the 2013-2014 school year are as follows:

Math:

1. 11z+33-3z+6 = 3z-6+4z-8Answer: x = -53
2. A force of 20 N acts upon a 5kg block. Calculate the acceleration of the object. Answer: 4 meters per second squared
3. 6x-3 = 6+5x Answer: x = 9
4. What is the value of x when 2x+3=3x-4? A) -7 B) -1/5 C) 1 D) 1/5 E) 7 Answer: E) 7
5. A typical high school student consumes 67.5 pounds of sugar per year. As part of a new nutrition plan, each member of a track team plans to lower the sugar he or she consumes by at least 20% for the coming year. Assuming each track member had consumed sugar at the level of a typical high school student and will adhere to this plan for the coming year, what is the maximum number of pounds of sugar to be consumed by each track team member in the coming year? A. 14 B. 44 C. 48 D. 54 E. 66 Answer: D. 54
6. Sales for a business were 3 million dollars more the second year than the first, and sales for the third year were double the sales for the second year. If sales for the third year were 38 million dollars, what were sales, in millions of dollars, for the first year? A. 16 B. 17.5 C. 20.5 D. 22 E. 35 Answer: A. 16
7. Ding's Diner advertised this daily lunch special: "Choose 1 item from each column—only $4.95!" Thus, each daily lunch special consists of a salad, a soup, a sandwich, and a drink.

Salads	**Soups**	**Sandwiches**	**Drinks**
cole slaw	onion	meat loaf	milk
lettuce	tomato	chicken	cola
potato		hamburger	coffee
		ham	tea
		tenderloin	

How many different daily lunch specials are possible? Answer: 120

8. A DVD player with a list price of $100 is marked down 30%. If John gets an employee discount of 20% off the sale price, how much does John pay for the DVD player? Answer: 56 Dollars
9. The distribution of Jamal's high school grades by percentage of course credits is given in the circle graph below. What is Jamal's grade point average if each A is worth 4 points; each B, 3 points; and each C, 2 points? Answer: 3.6

Science:

1. How many significant figures are in the number 0.00750? Answer: two
2. Constant force acting on a body experiencing no change in its environment will give the body? A) Constant acceleration B) Constant speed C) Constant velocity D) Zero acceleration Answer: A) Constant acceleration

3. An aqueous solution in WHICH concentration of –OH ions is greater than that of H+ ions? A) Basic B) Acidic C) Neutral D) Equilibrium Answer: A) Basic
4. Based on the information in Table 2, which of the following figures best illustrates the appearance of the filter paper after Sample 1 was analyzed? Answer: F) The filter where the blue color appeared at 0.60 R_f and the yellow color appeared at 0.78 $R_{f.}$
5. Based on the information in Table 1, to best identify a metal ion using paper chromatography, one should know the:
   A. spot color for the ion only
   B. distance the solvent traveled only
   C. R_f value and spot color for the ion only
   D. distance the solvent traveled and spot color of the ion only
   Answer: C. Rf value and spot color for the ion only
6. Based on the results of Experiment 1, which of the following graphs best shows the relationship between the temperature and the distance of the ring from the HCl swab? Answer: (D)
7. Science Problem: Which graph represents the total heat developed from time t = o by a resistor carrying a steady current? Answer: (A)
8. Science Problem: A beam of light is incident on a rectangular opening in the front of a box, as shown in the side view above. The back of the box is open. After passing through the box, the light is incident on a screen. The following devices may be in the box, positioned as shown. Which device could produce a tiny spot of light on the screen? Answer: A. Convex Lens

G3. Focus Team Activities

G3.1 Robotics Team

After the Kick-off, the following Thursday on January 9th 2014 the build season had begun. The build season consisted of eight people, ranging from sophomores to seniors. At the beginning of the build season the team missed the first three build days in the week due to the school district closing because of snow storms. The team works at the school building in Thurgood Marshall, since we worked under the district and the schools closes; the team cannot enter the building and work in the shop. While the team was out from the snow storm they was assigned to watch the YouTube series "Robot-in-three-days" and get ideas for the competition playing piece. After the school closings were finally over, the team met at school finally to begin the build season. The first thing the team did was discuss what they learned from "Robot-in-three-days". One thing the team noticed was that the robot in three days robot had catapults to launch the ball into the high goals. Including the discussion the team talked about what we want the robot to do, how to play the game? How to play on offense? How to play defense? Strategies? Etc…Than after the discussion the team thought of ideas of our own shooting, picking up, and hopper system designs and drew them on the board. After the first week of the build season (more like two days), the team decided on what kind of drive base we wanted; after consensuses the team decided to build a wide base, so some of the team broke into the building team for the base, while others decided on what offensive design they wanted. After the base was completed the second week, the group attempted to finalized the shooting and pick up designs, then went into the prototype stage, the ideas were wheel shooter or the catapult. The third week was about prototyping, making the wheel shooter and catapult, and whichever one seem to work the best and completed by week three the team would go with that idea and begin finalizing the

shooting design. After the time of prototyping, the team concluded on a wheel shooter; once deciding on using wheels to shoot the ball, the team went into final product design. Once we figured out the pros and cons of the wheel shooter we realized that we could turn the shooter on the side. The shooter originally started straight up and down, but the team realized that we was breaking a FIRST FRC rule, the shooter sat to high and it would extend more than 20 inches out of the base, which is illegal in FIRST FRC. Once the fifth week begun the team began assembling the whole robot: wires, pneumatics, hardware, programming etc… The robot was finally finished on the fifth week with practice time under its belt. The team was happy with the design and performance. And on the sixth week, the team finally "bagged & tagged" the robot for its first competition in St. Louis, MO.

G4. Club Field Trips

Throughout the school year the Math and Science Club went on field trips to places relevant to advancing student interest in the club and STEM applications. These trips included:

G4.1 FIRST Robotics Kickoff

On January 4, 20143 the FRC kickoff was held at the Dayton Regional STEM High School in Dayton, OH. Captain Mitchell Cowan toke Co-captain Tarrick White, members Shepria Pointer, Tyrone Berry, Malik Bursey, Kadijah Taylor, Khayln Miller, and Sade Foster, Alumni members Chris Ray, Eliza Straughter, and Brittany Davis-Rowe, and Mentors Shane Howard and Jeremy Warren. This year's game "Aerial Assist" kick-off was held with team 3138, the Innovators robotics. The kick-off started with everyone in the cafeteria, donuts and coffee were served for breakfast. Once the game kick-off video was ready the Cougarbots and the Innovators came together to watch it on a big projector. After the game video, different groups broke off; one team put together the mock game field in the other room, the next group was dealing with the rules and strategy. The rules and strategy group sat together and went through the game manual consisting of the field dimension, object piece dimension, end game challenge, technical fouls etc… After learning about the game rules and the objective, the group diverged and elaborated on questions and clarifications with some FRC mentors. After the group discussion on the rules, everybody meet in the open space with the field once the other team was done with the field. Once everyone met with the field, the team broke down into alliances, with each person as a "robot". An alliance in robotics is three robots, two alliances play on the field, meaning six robots on a field per game. Once teams were selected, we mocked up the game, actual playing with the ball and people shooting through the goals. With this idea, people were able to think of different strategies for offense, defense, and other strategies for working together. After everyone played at least three times everyone gather around to discuss what they learned and what worked and didn't work.

G4.2 FIRST Robotics St. Louis Regional Competition

On March 12 – 15, 2014 the robotics team went to the St. Louis Regionals in St. Louis, MO. This competition was the first competition the team competed in to start the 2014 FIRST Robotics season in the game "Aerial Assist". Captain Mitchell Cowan, Co-Captain Tarrick White and members Kadijah Taylor, Sade Foster, Tyrone Berry, Malik Bursey, and Khayln Miller attended this Competition. Mr. Shane Howard was the only mentor that attended. This competition was known to the team as the ice breaker competition, it was used to get more of a feel for the pace of the competition, where we could "find our game" and how other teams made

and competed with their robots. The team competed well in our matches. The team finished 27 out of 45 teams, with a recorded of 5-6-0. The robot performed well with no major breakdowns. The team also competed for the Chairman's Award with their video that can be viewed at the following url: http://youtu.be/vL2eALCrX9I.

G4.3 FIRST Robotics Queen City Regional Competition

: On March 26 - 29, 2014 the FRC Robotics team went to the Queen City Regional Competition in Cincinnati, OH. Captain Mitchell Cowan toke Co-Captain Tarrick White, Secretary Khayln Miller, and members Kadijah Taylor, Sade Foster, Tyrone Berry, and Malik Bursey. He was also accompanied by, team mentors, Mr. Henry Noble, Ms. Glenda Konechney, Mr. Jeremy Warren, of Booz Allen Hamilton, Mr. Shane Howard, of Isaac Fluid Power, and Captain William Indelicato, of Wright Patterson Air Force Base.

At the competition, the team faced several problems. The first problem faced was passing the inspection. The students had to fix a few bumpers because they had become damaged in travel and the students had to replace the kill switch, also known as the circuit breaker. After these issues were corrected the students passed inspection with a robot that weighed in at 119.7 lbs. The next problem that was faced was dealing with the drive train. The students were having a problem getting the drive train to drive straight. They figured out that they weren't getting as much power as they were supposed to. Once the team figured out how to make the best of their flaws they had a pretty good competition. They were picked for an alliance in the elimination rounds and were winners of the 2014 Queen City Regional with team 16, the Bomb Squad from Arkansas, and team 447, team Roboto. This got the team an invitation to the World Championships. The team also competed for the Chairman's Award and two senior members competed for the Dean's List.

G4.4 FIRST World Championship

After being a part of the winning team at Queen City Regional in Cincinnati, Ohio in March, team 2665 was invited to the World Championship in St. Louis and took place on April 23 through April 27th 2014. Dayton Public Schools sponsored our world championship travels with a 50 passenger bus to St. Louis, Missouri. Some mentors traveled along with the team. After arriving in St. Louis the team unpacked at the Double Tree hotel and met some teams such as the Innovators team 3138 and other teams such as rookie teams. One the first day of arrival teams were introduced to their pits then allowed to unpack the robot out of the crate. For this competition the team had to store the robot in a crate to ship off to competition a couple days ahead of time. Once the robot was unpacked and the team pit area was set up the team worked on the robot. The team wanted to switch out cylinders and use "double-acting" cylinders on the robot so the shooter mechanism can move down and up faster then before. Double acting cylinders are cylinders that can project out fast and retreat fast due to its spring mechanism, this change would help the robot inbound faster. One the next day the team was given practice matches, the team had a great run on this day competing against some of the top teams in the world. At the end of the day the team finished 3-2 with a rank of 33rd out of 100. On the third day the team went back into competition, but the day was ruff due to other robot out competing us. The match ups were odd, and at the end of the competition day we finished 3-6 and finished the world competition at 79th out of 100.

The team had a great experience and learned a lot from the competition. The team got a chance to go to a baseball game to watch the St. Louis Cardinals to the Pittsburg Pirates on the

behalf of one of our member's fathers who is a Top Chief. We were treated to a sky box in the stadium and also had a parade with FIRST around the diamond before the game begun. One the day after that the team was then invited to a pizza party with the innovators team 3138.

On the last day of competition we attended the FIRST "finale" and team 3138 funded the team's tickets. The finale was held in the competition arena and had different sections of fun; the first section had a game lounge sponsored by Microsoft with 10 Xboxes, and flat screen TVs, the next section had a glow dance floor for people to wear neon scraps and necklaces, the next part had a carnival area for carnival games, bounce houses, food, etc… Just like a normal carnival in a city. After the Finale the team drove through the city with some of the innovators back to the hotel.

G4.5 Trip to Academy of Model Aeronautics Museum

In the Fall of 2013 the students took a trip to Muncie, IN to visit the Academy of Model Aeronautics Museum. We got a tour of the museum from our guide, Ms. Emily. We learned a lot about the history of model aircraft and it's progression. What we found very interesting was actual model aircraft made to do exactly what real airplanes were doing. In addition, the students got to watch a model aircraft that had been flown all over the United States fly for the last time. The Flying Cougars really enjoyed being the last people to see that airplane's last flight, and it produced a good feeling in all the students. The last activity we did before the Flying Cougars deported was challenging but fun. We built airplanes from a kit, but learned how to modify the kit parts to improve the stability of the plane in flight. The Flying Cougars got a better understanding of the fundamentals of planes. Flying the planes outside we learned how wind can be challenge for smaller planes depending on the direction one tries to fly.

G4.6 FIRST Ohio State Robotics 2014 Championship

On May 17, 2014 the team 2665, the Cougarbots, hosted the 2014 state robotics competition at Thurgood Marshall high school. They also competed against the top 24 teams in the state. The Cougarbots placed third and received a trip to the university of Cincinnati basketball game.

G4.7 Science Fair Cycle and Awards

Every year, any student who wishes to be in our club must participate in the school science fair. At the school science fair, we had a great number of participants. And the Dayton District Science Fair, we had the largest number of students from any high school there and also conquered awards from every category. For the West District Science Fair, our club took about 10 students and the awards that our school took home are listed below:

G4.8 Research Projects:

Below are the results of Thurgood Marshall's Building Science Fair.

- Kadijah Taylor (Superior Rating)
- Khayln Miller (Superior Rating,)
- Mitchell Cowan (Superior Rating,)
- Sade Foster
- Malik Bursey
- Tarrick White (Superior Rating,)
- Tyrone Berry

- Shepria Pointer

Below are the results from the District Science Fair

- Kadijah Taylor (Superior Rating)
- Khayln Miller (Superior Rating)
- Mitchell Cowan (Superior Rating,)
- Sade Foster (Superior Rating,)
- Malik Bursey (Superior Rating,)
- Tarrick White (Superior Rating,)
- Tyrone Berry (Superior Rating,)
- Shepria Pointer (Superior Rating,)

Below you will find all of the research projects that placed and won awards at the regional level. This year, we also had five projects receive Superior ratings and moved on to the State Science Fair competition. These were Khayln Miller, Grade 11, , Mitchell Cowan, Grade 12, Shepria Pointer, Grade 12, Malik Bursey, Grade 11, and Kadijah Taylor, Grade 12.

- 5 Superior Projects qualify for State Science Day and 12 Special Awards
    - ISA $100 Cash Award and Certificate – Kadijah Taylor Grade 11
    - CSU Manufacturing Engineering Department – Boeing Scholarships of $3000 per year (renewable 3 more years for total of $12,000) Jasmin Sanford, Kadijah Taylor Grade 11
    - United States Air Force Certificate of Achievement Award – Jasmin Sanford, Kadijah Taylor Grade 11, and Khayln Miller Grade 10

Next you will find the abstracts of all Club Members. State participants will be stated. Each abstract will be headed with students name, grade, and the title of their project.

G4.8.1 Kadijah Taylor, Grade 12, CFL v. LED: Heat v. Illuminance (State Participant)

Compact fluorescent light (CFL) and Light-emitting diode (LED) are energy- saving light bulbs. The problem was does a 12 watt LED light bulb with 820 lumens produce less heat than a 13 watt CFL light bulb with 825 lumens in a 30 minute time frame with a 120 volt power supply in a box with a total surface area of 951.7 inches? This problem helps determines if energy-saving light bulbs are safe for the household.

The hypothesis was If a 12 watt LED light bulb with 820 lumens and 13 watt CFL bulb with 825 lumens are put into a lamp mounted in the lid of a box with the height of 9.875 inches and dimensions of 15.75 x 12.5 x 9.875 inches and a 951.7 inch surface area, then the rate of change for temperature inside the box will be slower for the LED bulb within a 30 minute time frame with a 120 volt power supply because there is no mercury gas in a LED light bulb to heat and there is only straight current flow that flows through the LED light bulb.

A controlled environment was created. The separate trials were run in the following order: Illumination, Temperature, Illuminance v. temperature.

There was no direct correlation between temperature and illuminance for the bulbs. The amount of illumination never stabilized. The LED had a lower percentage of change for temperature being 7.8%. The LED’s lower percentage of change for temperature shows it is safer than the CFL.

G4.8.2 Shepria Pointer, Grade 12, Changing the Mechanism of a Drip Coffee Maker (State Participant)

The purpose of this experiment was to see if changing the mechanism of a coffee maker using reverse engineering, enhance it's hot plate to heat coffee and water at a faster rate. If you change the aluminum hot plate of a drip coffee maker to a thinner iron hot plate, then I think it will enhance the temperature to stay longer with the coffee making 4, 6, 8, 10, and 12 cups of coffee because iron is also a good conductor of heat and it can get heated faster because it is thinner. It can improve the coffee makers heat transfer and structure. The methods needed for this project are that you need to get a drip coffee maker. Test the coffee maker out using just water. Make 4,6,8,10, and 12 cups of coffee with water and check the temperature before it was brewed, after it was brewed, and after through coffee is set on the hot plate for 15 minutes. After the coffee is finished clean it and begin taking it down (Reverse. Engineer). Do these same steps with the new iron hot plate. While taking it apart, take pictures and document step by step. In conclusion, the new hot plate did not get as hot as the original aluminum hot plate. The results showed the hypothesis was incorrect.

G4.8.3 Mitchell Cowan, Grade 12, Induced Drag Coefficient (State Participant)

This project is about induced drag. When testing swept back, delta, and rectangular wing designs at 5°, 15°, and 25° angles of attack, and wind speeds going 40mph (full-speed) and 20mph (half-speed) in a wind-tunnel, which will produce the least amount of induced drag?

Induced drag slows an aircraft down and increases the risk of stall; stall is the turbulence that overcomes the airfoil which causes the aircraft to lose lift and drop airspeed which results in poor performance and deadly accidents.

The hypothesis states that “If delta, swept-back, and rectangular shaped wings are tested in a wind-tunnel at 20mph and 40mph and 5°, 15° and 25° angle of attack, then the delta wing will have the least amount of induced drag because the 90° trailing edge (back) of the delta wing produces less turbulence increasing the speed compared to the swept-back’s open wing which produces a lot of turbulence along the fuselage (body of the aircraft) creating drag, the rectangular wing has a straight wing configuration which increases drag due to its 90° leading edge (front) and 90° trailing edge.”

In result, the hypothesis was correct; in fact, the delta wing had the least amount of induced drag compared to the swept-back and rectangular wing at 40mph and 5° angle of attack. The independent variables were wind-speed, wing size, angle of attack, and wings. The dependent variables were the amount of lift produced, coefficient of lift calculated and the induced drag coefficient calculated. The control was wing surface area.

G4.8.4 Khayln Miller, Grade 11, Lift to Drag Ratio (State Participant)

The purpose of this experiment was to find out which wing shape would produce the greatest lift to drag ratio between rectangular, elliptical, delta, and swept back shaped wings. The hypothesis is if four different airfoil designs with winglets, swept, delta, rectangular, and elliptical, are tested in a wind tunnel at three different angles of attack looking for the greatest lift to drag ratio, then the swept back design will produce the greatest lift to drag ratio because it’s shape produces more lift than the other wing shapes and according to NASA it produces much less drag in the process.

The procedure was as follows: First, an airfoil was placed in the wind tunnel at a 5 degree angle. Next, the wind tunnel was turned on at half speed. After that, how much lift and drag that got produced was recorded. Next, the wind tunnel was switched to full speed and the lift and

drag was recorded. This was done three times and the average for full and half speed was taken. Then the angle of attack changed to 15 degrees and 25 degrees and the same steps were done. Finally, these steps were repeated with the other wing shapes.

The hypothesis was correct. The swept back shaped wing had the greatest L/D ratio because it produced more lift and lower drag than the other wing shapes due to its shape which has lateral stability and little induced drag because of its wing tapers.

G4.8.5 Malik Bursey, Grade 11, Electric v. Induction (State Participant)

The purpose of this project is to test one of the many difference between standard electric cooking and developing induction cooking, the focus of this project is speed. I choose this project because I find interest in magnetic and its many uses. I was introduced to induction, which use magnetic to cook, by one of my mentors. It is supposed to be the ‘new age’ of cooking and have many advantages over standard electric. This project was testing over of these advantages, cook time. The question being answered is; between an electric coil hotplate and a countertop induction burner, which can more quickly heat a 5 inch diameter base by 3 inch height stainless steel pot to point of boiling 2 cups of water, placed inside the pot, at a set temperature of 360°F. The approach taken to answer is practically written in the question. I used the specified pot to boil 2 cups of water on each of the cook wares and recorded the time taken to boil the water, in multiple trials. Results show that the induction burner took significantly less time to boil the water than the electric hotplate. This proves that induction is an improvement to electric in term of speed or cook time.

G4.8.6 Sade Foster, Grade 11, Acids in Fruit Juices

The purpose of this project is to find out which fruit juice has lowest pH level, which means it is more acidic. The hypothesis is if 50 mL of lemon juice, orange juice, apple juice, pineapple juice, grape juice or grapefruit juice was put into a beaker and heated to a temperature greater than 159^{o}F, then the level of acid would decrease because heat kills the ascorbic acid in fruit juices. Acids are molecules that can be split apart in water and release hydrogen ions; in particular, having a pH of less than 6. pH stands for power of hydrogen. A pH sensor is an electronic device used for measuring the pH of a liquid. A typical pH meter consists of a special measuring probe connected to an electronic meter that measures and displays the pH reading. The methods are Create the fruit juice, Put 50 mL of fruit juice into a beaker, Use pH sensor to measure the acidity and record the results. Materials are 250 mL beaker, Orange Juice, Apple Juice, Grape Juice, Pineapple Juice, Grapefruit Juice, Safety Goggles, pH sensor. Results the hypothesis that was stated was correct. The fruit juices level of acid did decrease. Lemon juice had the lowest pH.

G4.8.7 Tarrick White, Grade 10, Solar RC Cars

A solar vehicle is an electric car powered completely or significantly by direct solar energy. Usually, photovoltaic (PV) cells contained in solar panels convert the sun`s energy directly to useable energy. The purpose of doing this project is to learn away how to turn actual size car to a solar powered car. Purchase a 9.6 volt RC car driving around apps are what you can do and its performance with the battery before is converted to a solar car. the number trials attempt it will be 8. The hypothesis is that the solar panel give the battery more operation time because it has a high charge rate. The results of the project show that the solar panel increased operation time of the RC car. The experimentation with difficult because I had to figure out a way to mount a solar panel on to the truck and had to make sure the wire's stay intact.

G4.8.8 Tyrone Berry, Grade 10, Musical Sounds

The purpose of this project is to find out how much tension it takes for nylon, bronze, and steel strings to have the same frequency to match their pitch? The hypothesis is if nylon, steel and bronze E strings are at the same length then test them with spring scales then steel will meet the correct pitch because steel can take up to 100 pounds of pressure while nylon only takes about 80 pounds of force.

The procedure was as follows: first, gather guitar, sound device and other materials. Then attach the spring scale to the body of the guitar, above the strings. Then attach the guitar next to the strings. Next hook the microphone onto base of the guitar. The set up logger pro on the computer. Next set the set the spring scale to 3000n. Then pluck the first guitar string and record data. Record 3 times. Finally repeat the steps above and set the spring scales to 3500n and 4000n.

The hypothesis was incorrect. The bronze strings at 4000n of force matched the correct frequency because the wire wrapped around a core wire to provide deeper and more sustained mid-range and bass tones for your acoustic guitar.

G4.9 Installation and Award Ceremony

The Installation and Awards Banquet was held on 14 May 2013 at 4:00pm in Thurgood Marshall Auditoria. The club officers for the 2014-2015 school years were installed. Kadijah Taylor the Outgoing President installed Khayln Miller as the new President, then Khayln Miller installed the remaining officers. Tarrick White was installed as the new Vice President, and Tyrone Berry was installed as the new Secretary. Each officer had to say their oath that reflected their responsibilities in the charter. After installation the Awards Ceremony was held. The awards were for the club members’ achievements throughout the year. Mr. Mike Zywien was our speaker and spoke to the members about how to be a leader.

Mr. Mike Zywien was the speaker at the Installation and Awards Ceremony on May 14, 2014. Mike Zywien joined SAIC (Science Applications International Corporation, now Leidos Inc.) as a Director of Programs in the Reconnaissance & Surveillance Operation, Technology & Services Business Unit, in September 2007. He currently manages the Blue Devil program, an Air Force Research Lab multi-INT ISR program that was fielded overseas in October 2010.Prior to joining SAIC (Leidos), Zywien led Theater Airborne Reconnaissance System (TARS) product line development, production, sustainment, and deployment for BAE Systems’ ISR Division in Greenlawn, NY. He had P&L responsibility for a $30M/year product line, planned and executed business strategies, and led a 100-person, multi-functional team. Zywien secured and executed a $50M Egypt TARS program, a $20M TARS Spares purchase, a $13M TARS Data Link upgrade program, and a $5M/year TARS Sustainment program. He also led two very successful IR&D projects to spur product line growth. Zywien began his defense industry career as a Principal for SRA International, Inc. There, he helped lead a team that captured a key $45M Information Warfare IDIQ contract that more than doubled the revenues of the Dayton SRA Office. He also planned and executed an AFMC Command Survey that assessed the effectiveness of intelligence support to all USAF acquisition programs. The study provided the foundational support for a variety of AFMC/IN strategic planning initiatives. Zywien served on active duty in the United States Air Force from 1982 to 2003, specializing in acquisition management, research, and intelligence. His assignments included Global Hawk Chief of Integration; Deputy Division Chief in the Reconnaissance Systems Wing where he led a diverse portfolio of EO, IR, Hyper spectral, and SIGINT projects and programs; Chief of Integration for the Joint SIGINT Avionics Family Program; AFMC Command Inspector; Chief of the HPM Counter space Research

Branch, AFRL Directed Energy Directorate; Foreign Systems Analyst, National Air and Space Intelligence Command and DESERT STORM Joint Intelligence Center; and Chief of the Joint STARS Radar Division. Zywien retired in 2003 with the rank of Lt Colonel. Zywien was born on September 11, 1953. He received a BA in Sociology from Holy Cross College, a BSEE from the University of New Mexico, and an MS in Systems Engineering from AFIT. Prior to joining the US Air Force, he was a teacher/coach at Blackstone-Millville Regional Junior-Senior High School in Blackstone, MA. He is a member of the Air Force Association, the Military Officers Association of America, the American Legion, the USO, and the Association of Old Crows. Zywien lives in Kettering, OH with Shirley, his wife of 33 years. They have four children (3 boys and a girl) and eight grandchildren (7 girls, 1 boy). Mr. Mike Zwyien is the program manager for the project “Blue Devils” which is a project where small planes are sent to soldiers and used to prevent soldiers from walking into an area blind. The soldiers send the plane to fly overhead of the area they are about to walk into and the plane gathers the information and sends it to the soldiers so that they are prepared.

After Mr. Zywien finished speaking he was given a small token of appreciation. The token of appreciation was a .The first set of awards was for the Outgoing Officers. Khayln Miller received a stationary pin set for his role as secretary, Kadijah Taylor received a gavel set for her role as President and Mitchell Cowan received a gavel set for his role as Vice President. The next group of awards was the robotics awards Tarrick White and Mitchell Cowan were awarded a mug for their leadership of the robotic team and a game logo pin. The other members, Kadijah Taylor, Sade Foster, Tyrone Berry, Malik Bursey, and Khayln Miller were awarded a game logo pin for their participation. Following the individual awards for robotics the team presented the school with the regional and state trophies. The next award was the President Choice Award that was awarded to Tarrick White for his hard work with recruitment. Next the Gifted and Advanced students were awarded for their participation in the program and the students that went to the regional Science fair was recognized. The next group of awards was for the state science fair participants. Each participant that received a superior rating received an Air force medal. They were Kadijah Taylor, Mitchell Cowan, Malik Bursey, Jasmin Sanford and Khayln Miller. The Students who received an excellent received a pen, That student was Shepria Pointer. Following the presentation of the awards to the students the group presented the school with the Harold C. Shaw award. The next award was for the mentors of the club. They received a pocket tools set that read Thurgood Marshall Math & Science Club Mentor. The mentors were Donnie Saunders, Ms. Sharon Goins, Mr. Temmesfeld, Mr. Mike Zwyien, Mr. Kurtz Miller, and Mr. Samuel Eckhart. The last group of awards was called the Special Awards giving to student for exceptional achievements. Mr. Tyrone Berry received an award for the most growth, and the Senior members, Kadijah Taylor, Mitchell Cowan, and Shepria Pointer, was presented with their sashes that they can wear at graduation.

G4.10 Club Charter Modifications

The Math and Science Club made some changes to their charter to make the club run more smoothly. The charter is similar to the constitution in that it is a living document, changes were made on subjects that were not specified or mention that sometimes made running the club harder. The Math and Science Club Charter changed the year from 2013 - 2014 to 2014-2015.

APPENDIX H
Research Projects Academic Year 2013-2014

H1. "Lift to Drag Ratio" by Khalyn Miller, Grade 11

H1.2 Abstract

The purpose of this experiment was to find out which wing shape would produce the greatest lift to drag ratio between rectangular, elliptical, delta, and swept back shaped wings. The hypothesis is if four different airfoil designs with winglets, swept, delta, rectangular, and elliptical, are tested in a wind tunnel at three different angles of attack looking for the greatest lift to drag ratio, then the swept back design will produce the greatest lift to drag ratio because it's shape produces more lift than the other wing shapes and according to NASA it produces much less drag in the process.

The procedure was as follows: First, an airfoil was placed in the wind tunnel at a 5 degree angle. Next, the wind tunnel was turned on at half speed. After that, how much lift and drag that got produced was recorded. Next, the wind tunnel was switched to full speed and the lift and drag was recorded. This was done three times and the average for full and half speed was taken. Then the angle of attack changed to 15 degrees and 25 degrees and the same steps were done. Finally, these steps were repeated with the other wing shapes.

The hypothesis was correct. The swept back shaped wing had the greatest L/D ratio because it produced more lift and lower drag than the other wing shapes due to its shape which has lateral stability and little induced drag because of its wing tapers.

H1.3 Introduction

H1.3.1 Question

If four different airfoil designs, elliptical, rectangular, swept back, and delta with winglets are tested in a wind tunnel at three different angles, 5, 15, and 25 degrees of attack, which airfoil will have the greatest lift to drag ratio?

H1.3.2 Hypothesis

If four different airfoil designs with winglets, swept, delta, rectangular, and elliptical, are tested in a wind tunnel at three different angles of attack looking for the greatest lift to drag ratio, then the swept back design will produce the greatest lift to drag ratio because it's shape produces more lift than the other wing shapes and according to NASA it produces much less drag in the process. An airplane has a high L/D ratio if it produces a large amount of lift or a small amount of drag. I also found out that an aircraft with a high L/D ratio can carry a large payload for a long time over a long distance and the C-17 which is a cargo plane has swept back wings.
The independent variable in this project is the airfoils. The dependent variable in this project is the lift to drag ratio.

H1.4 Background

This project is a continuation project from my project last year titled "Which Has More Lift". The reason this project was chosen is because flight interests me very much. This summer I had the opportunity to work at Wright-Patterson Air Force Base and I learned some things about aerodynamics and wind tunnels. This increased my interest in flight and pushed me in the direction to be an aerospace engineer.

H1.4.1 How an Airplane Flies

In order for an airplane to fly you need 4 things: Weight, Thrust, Lift, and Drag. For this project the focus will be on the lift and the drag of flight.

H1.4.2 What is Weight?

Weight - Weight is a force that is always directed toward the center of the earth. The magnitude of the weight depends on the mass of all the airplane parts, plus the amount of fuel, plus any payload on board (people, baggage, freight, etc.). The weight is distributed throughout the airplane. But we can often think of it as collected and acting through a single point called the center of gravity. In flight, the airplane rotates about the center of gravity. Lift has to be greater than the weight in order to fly.

H1.4.3 What is Thrust?

Thrust - To overcome drag, airplanes use a propulsion system to generate a force called thrust. The direction of the thrust force depends on how the engines are attached to the aircraft. On some aircraft, such as the Harrier, the thrust direction can be varied to help the airplane take off in a very short distance. The magnitude of the thrust depends on many factors associated with the propulsion system including the type of engine, the number of engines, and the throttle setting. For jet engines, it is often confusing to remember that aircraft thrust is a reaction to the hot gas rushing out of the nozzle. The hot gas goes out the back, but the thrust pushes towards the front. Action <--> reaction is explained by Newton's Third Law of Motion. The motion of the airplane through the air depends on the relative strength and direction of the forces shown above. If the forces are balanced, the aircraft cruises at constant velocity. If the forces are unbalanced, the aircraft accelerates in the direction of the largest force.

H1.4.4 What is Lift?

> “The amount of lift generated by an object depends on the size of the object. Lift is an aerodynamic force and therefore depends on the pressure variation of the air around the body as it moves through the air. The total aerodynamic force is equal to the pressure times the surface area around the body. Lift is the component of this force perpendicular to the flight direction. Like the other aerodynamic force, drag, the lift is directly proportional to the area of the object. Doubling the area doubles the lift.” (NASA)
>
> “There are several different areas from which to choose when developing the reference area used in the lift equation. Since most of the lift is generated by the wings, and lift is the force perpendicular to the flight direction, the logical choice is the wing planform area. The platform area is the area of the wing as viewed from above the wing, looking along the "lift" direction. It is a flat plane, and is NOT the total surface area (top and bottom) of the entire wing, although it is almost half that number for most wings. We could, in theory, use the total surface area as the reference area. The total surface area is proportional to the wing planform area. Since the lift coefficient is determined experimentally, by measuring the lift and measuring the area and performing the necessary math to produce the coefficient, we are free to use any area which can be easily measured. If we choose the total surface area, the computed coefficient has a different value than if we choose the wing planform area, but the lift is the same, and the coefficients are related by the ratio of the areas.” (NASA)

“Lift is the force that directly opposes the weight of an airplane and holds the airplane in the air. Lift is generated by every part of the airplane, but most of the lift on a normal airliner is generated by the wings. Lift is a mechanical aerodynamic force produced by the motion of the airplane through the air. Because lift is a force, it is a vector quantity, having both a magnitude and a direction associated with it. Lift acts through the center of pressure of the object and is directed perpendicular to the flow direction. There are several factors which affect the magnitude of lift.” (NASA)

“Lift occurs when a moving flow of gas is turned by a solid object. The flow is turned in one direction, and the lift is generated in the opposite direction, according to Newton's Third Law of action and reaction. Because air is a gas and the molecules are free to move about, any solid surface can deflect a flow. For an aircraft wing, both the upper and lower surfaces contribute to the flow turning.” (NASA)

Lift Equation – L= Cl x P x V^2/2 x A
Lift= coefficient x (density x velocity squared/two) x wing area

H1.4.5 What is Drag?

“Drag is the aerodynamic force that opposes an aircraft's motion through the air. Drag is generated by every part of the airplane (even the engines!).” (NASA)

“Drag is a mechanical force. It is generated by the interaction and contact of a solid body with a fluid (liquid or gas). It is not generated by a force field, in the sense of a gravitational field or an electromagnetic field, where one object can affect another object without being in physical contact. For drag to be generated, the solid body must be in contact with the fluid. If there is no fluid, there is no drag. Drag is generated by the difference in velocity between the solid object and the fluid. There must be motion between the object and the fluid. If there is no motion, there is no drag. It makes no difference whether the object moves through a static fluid or whether the fluid moves past a static solid object.” (NASA)

“Drag is a force and is therefore a vector quantity having both a magnitude and a direction. Drag acts in a direction that is opposite to the motion of the aircraft. Lift acts perpendicular to the motion. There are many factors that affect the magnitude of the drag. Many of the factors also affect lift but there are some factors that are unique to aircraft drag.” (NASA)

“We can think of drag as aerodynamic friction, and one of the sources of drag is the skin friction between the molecules of the air and the solid surface of the aircraft. Because the skin friction is an interaction between a solid and a gas, the magnitude of the skin friction depends on properties of both solid and gas. For the solid, a smooth, waxed surface produces less skin friction than a roughened surface. For the gas, the magnitude depends on the viscosity of the air and the relative magnitude of the viscous forces to the motion of the flow, expressed as the Reynolds number. Along the solid surface, a boundary of low energy flow is generated and the magnitude of the skin friction depends on conditions in the boundary layer.” (NASA)

Drag Equation: D = Cd x (p x v^2/2) x A

H1.4.6 Lift to Drag Ratio

"Because lift and drag are both aerodynamic forces, the ratio of lift to drag is an indication of the aerodynamic efficiency of the airplane. Aerodynamicists call the lift to drag ratio the L/D ratio, pronounced "L over D ratio." An airplane has a high L/D ratio if it produces a large amount of lift or a small amount of drag. An aircraft with a high L/D ratio can carry a large payload, for a long time, over a long distance. For glider aircraft with no engines, a high L/D ratio again produces a long range aircraft by reducing the steady state glide angle at which the glider descends. The lift to drag ratio is lift divided by drag.

H1.4.7 Bernoulli's Principle

Bernoulli's Principle- Works on the idea that as a wing passes through the air, its shape make the air travel more over the top of the wing than beneath it. This creates a higher pressure beneath the wing than above it. The pressure difference cause the wing to push upwards and lift is created.

H.1.4.8 What is Induced Drag?

"Induced Drag is an inevitable consequence of lift and is produced by the passage of an airfoil through the air. Air flowing over the top of a wing tends to flow inwards because the decreased pressure over the top surface is less than the pressure outside the wing tip. Below the wing, the air flows outwards because the pressure below the wing is greater than that outside the wing tip. The direct consequence of this as far as the wing tips is concerned is that there is a continual spilling of air upwards around the wing tip a phenomenon called 'tip effect' or 'end effect'. One way to appreciate why a high aspect ratio for a wing is better than a low one is that with a high aspect ratio, the proportion of air which moves in this way is reduced and therefore more of it generates lift"(SKYbrary).

"For the wing more generally, since the streams of air from above and below the wing which meet along the trailing edge are flowing at an angle to each other as they meet, they combine to form vortices, which, when viewed from the rear, rotate clockwise from the left wing and counter clockwise from the right. The tendency is for these vortices to move outwards towards the wing tip joining up as they do so. Eventually, by the time the wing tip is reached, one large wig tip vortex has formed and is shed" (SKYbrary).

"Most of these vortices are of course completely invisible but, in very humid air, the central core of a vortex may become visible because the air pressure within its center has reduced - and has therefore cooled - sufficiently for condensation to occur. The higher wing loading in a turn will also increase the strength - and the degree of reduced pressure - so that visible vortex cores are even more likely during turns. If close up to these vortices, they can also sometimes be audible!"(SKYbrary)

"Most of the air flowing off the top of a wing - 'downwash' - continues more or less horizontally towards the empennage because it is balanced by a corresponding upwash in front of the wing leading edge. In contrast, the upwards air movement which leads to vortex 'consolidation' at the tip is just outside the tip whereas the corresponding downward movement is just at the extremity of the wingspan so that the net direction of airflow past the wing is downwards. The lift created by the wing - which is by definition at right angles to the airflow, is therefore inclined slightly backwards and thus 'contributes' drag - induced drag" (SKYbrary).

The induced drag coefficient equation is:

Induced drag coefficient = lift coefficient ^ squared / pi * Aspect Ratio * efficiency factor
$Cdi = (Cl^2) / (pi * AR * e)$
Factors that tend to increase induced drag:
High weight, low efficient wing design, high altitude, low velocity, and low wingspan.

H1.4.9 Induced Drag vs. Drag

The difference in these two aspects of flight is drag is the opposition to flow due to every part of the aircraft while induced drag is the opposition to flow due to the wing.

H1.4.10 Form Drag

"We can also think of drag as aerodynamic resistance to the motion of the object through the fluid. This source of drag depends on the shape of the aircraft and is called form drag. As air flows around a body, the local velocity and pressure are changed. Since pressure is a measure of the momentum of the gas molecules and a change in momentum produces a force, a varying pressure distribution will produce a force on the body. We can determine the magnitude of the force by integrating (or adding up) the local pressure times the surface area around the entire body. The component of the aerodynamic force that is opposed to the motion is the drag; the component perpendicular to the motion is the lift. The lift and drag force act through the center of pressure of the object." (NASA)

H1.4.11 Wingtip Designs and Winglets

A wingtip is the tip of a wing. The design of the wingtip has an effect on lift and also affects the distribution of the lift along a wing and thus the wing's efficiency. The wingtip has become an important design criterion. Squared-off wingtips are aerodynamically more efficient than rounded tips. The square-off wingtip better restricts the passage of high-pressure air from the lower surface to the upper surface. When high-pressure air leaks to the upper surface it leads to low aerodynamic efficiency. Most of today's airplanes have simple squared-off tips. Winglets are wingtips turned vertically. Winglets go one step further in preventing the passage of high-pressure air from flowing around the lower surface to the upper surface. Winglets increase the effective length of the wing and thus increase the wing's efficiency without increasing its length.

H1.4.12 Angle of Attack

As a wing moves through the air, the wing is inclined to the flight direction at some angle. The angle between the chord line and the flight direction is called the angle of attack and has a large effect on the lift generated by a wing. When an airplane takes off, the pilot applies as much thrust as possible to make the airplane roll along the runway. But just before lifting off, the pilot "rotates" the aircraft. The nose of the airplane rises, increasing the angle of attack and producing the increased lift needed for takeoff. For this project I'm using a 5, 15, and 25 degree angle of attack because the 5 degree is a steady level flight, a 25 degree is ascending flight, and 15 is a median to read data as well.

H1.5 What are Wings? / Different Airfoils

H1.5.1 Wings

An airfoil whose principal function is providing lift.

The reason I chose these 4 wing shapes is two of them are modern (delta and swept back) and two are not used as much because they lack some aerodynamic benefits such as speed.

"Rectangular Wing: The rectangular wing, sometimes referred to as the "Hershey Bar" wing in reference to the candy bar it resembles, is a good general purpose wing. It can carry a reasonable load and fly at a reasonable speed, but does nothing superbly well. It is ideal for personal aircraft as it is easy to control in the air as well as inexpensive to build and maintain." (NASA)

"Elliptical wing: The elliptical wing is similar to the rectangular wing and was common on tail-wheel aircraft produced in the 1930s and 40s. It excels however in use on gliders, where its long wingspan can capture the wind currents easily, providing lift without the need for a lot of forward momentum, or airspeed." (NASA)

"Swept Wing: The swept wing is the "go to" wing for jet powered aircrafts. It needs more forward speed to produce lift than the rectangular wing, but produces much less drag in the process, meaning that the aircraft can fly faster. It also works well at the higher altitudes, which is where most jet aircraft fly." (NASA)

"Delta Wing: The delta wing advances the swept wing concept, pulling the wings even further back and creating even less drag. The downside to this however is that the aircraft has to fly extremely fast for this wing to be affective. This is why it's only found on supersonic aircraft (aircraft that flies faster than the speed of sound) such as fighter jets and the space shuttle orbiter. There were also two commercial passenger jets that used this wing design, the Russian TU-144 and BOAC's Concorde, both of which could cruise at supersonic speeds." (NASA)
Wing Equations:

- Rectangular: A=b*h (base*height)

4.7in*1.5in= **7.05 inches squared**

- Delta: A=1/2*b*h

½*3.8in*3.7in = **7.03 inches squared**

- Swept Back: A=Wing Span*Average Chord*2

Average Chord: (root cord + tip cord) / 2
1in*3.5in*2 = **7 inches squared**

- Elliptical: A= (3.14*span*chord) / 4

(3.14*6in*1.5in) / 4 = **7.07 inches squared**

H1.6 What are Wind Tunnels?

Figure H-1 Wind Tunnel Control Board

The wind tunnel I am using for my project is an Aerostream Wind Tunnel

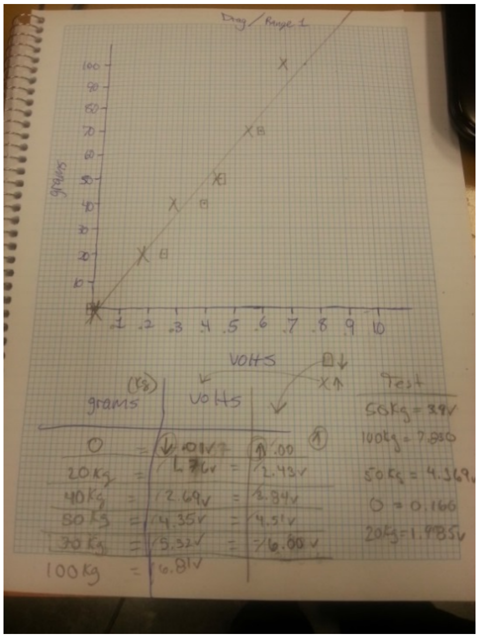
"Aerodynamicists use wind tunnels to test models of proposed aircraft. In the tunnel, the engineer can carefully control the flow conditions which affect forces on the aircraft. By making careful measurements of the forces on the model, the engineer can predict the forces on the full scale aircraft. And by using special diagnostic techniques, the engineer can better understand and improve the performance of the aircraft." (NASA)

"Wind tunnels are usually designed for a specific purpose and speed range. There are special tunnels for propulsion, icing research, subsonic, supersonic, and hypersonic flight, and even full scale testing. A wind tunnel may be open and draw air from outside the tunnel into the test section and then exhaust back to the outside, or the tunnel may be closed with the air recirculation inside the tunnel. The tunnel in the figure is a closed tunnel which we are viewing from above. The air inside the tunnel is made to move by the fan on the far side of the tunnel. In this figure, air continuously moves counter-clockwise around the circuit, passing over the model that is mounted in the test section." (NASA)

"Wind tunnels usually have powerful fans to move the air through the tube. The object being tested is placed in the tunnel so that it will not move. The air moving around the still object shows what would happen if the object were moving through the air. The object can be a smaller-scale model of a vehicle, one piece of a vehicle, a full-size aircraft or spacecraft, or even a common object like a tennis ball. Usually, the object carries special instruments to measure the forces produced by the air on the object. Engineers also study how the air moves around the object by injecting smoke or dye into the tunnel and photographing its motion around the object. Improving the flow of air around an object can increase its lift and decrease its drag." (NASA)

H1.6.1 Lift and Drag Calibration

For this project, lift and drag will be measured in grams. The bar that the wings are placed on in the wind tunnel has a strain gauge attached to it and by using it an electrical circuit can measure the strain put on it by the lift and drag force. This is measured in volts, but curves were used (force versus voltage) to change the voltage reading in to grams.



Lift: Reading in volts / 0.0103 = lift in grams

Drag: Reading in volts / 0.078 = drag in grams

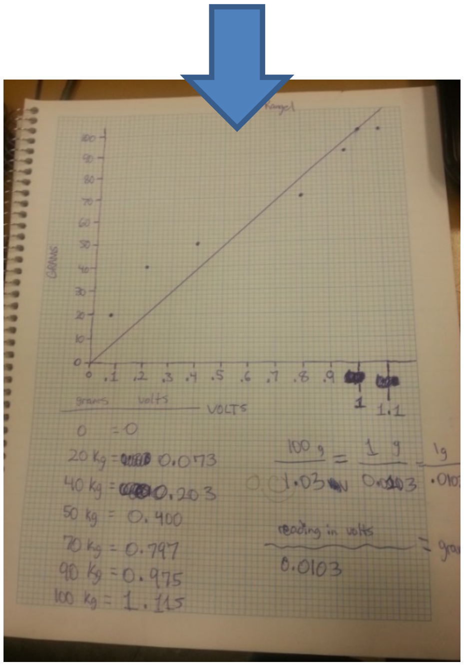


Figure H-2 L/D Calibrations

H1.7 Physics Behind How an Airplane Flies

Newton's Three Laws of Motion:

IV. Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.

Example: If a plane is descending to land and the thrust reverses are activated then the plane will slow down.

V. The relationship between an object's mass m, its acceleration a, and the applied force F is F = ma. Acceleration and force are vectors; in this law the direction of the force vector is the same as the direction of the acceleration vector.

Example: Force of a plane is equal to its mass or total weight times the acceleration or thrust.

VI. For every action there is an equal and opposite reaction.

Example: When you increase the angle of attack you will ascend higher.

H1.8 Materials and Methods

Materials:

12. Model Size rectangular shaped wing with winglets
13. Model Size elliptical shaped wing with winglets
14. Model Size swept shape wing with winglets
15. Model Size plane delta shape wing with winglets
16. Wind Tunnel
17. Four Screws & Nuts
18. Protractor
19. DATAQ Software
20. Laptop
21. Styrofoam Board
22. X-Acto Knife

Methods:

9. Place the first airfoil in the wind tunnel at a 5 degree angle.
10. Turn on the wind tunnel at half speed (20 mph).
11. Record how much lift & drag is produced using DATAQ Software.
12. Switch the wind tunnel to full speed (40 mph).
13. Record how much lift & drag is produced.
14. Do this three times and take the average for full and half speed.
15. Change the angle of attack to 15 degrees and 25 degrees and repeat steps 2-6.
16. Repeat steps 1-7 for the other three airfoils.

Table H-1 Trial Results

Trial	Angle of Attack	Speed (mph)	Lift (volts)	Drag (volts)	Lift (grams)	Drag (grams)
1	5	20	0.208	0.450	20.194	5.769
1	5	40	0.258	1.380	25.049	17.692
2	5	20	0.130	0.380	12.621	4.872
2	5	40	0.270	1.390	26.214	17.821
3	5	20	0.145	0.375	14.078	4.808
3	5	40	0.280	1.360	27.184	17.436
1	15	20	0.068	0.590	6.602	7.564
1	15	40	0.238	1.900	23.107	24.359

2	15	20	0.075	0.555	7.282	7.115
2	15	40	0.245	1.900	23.786	24.359
3	15	20	0.088	0.590	8.544	7.564
3	15	40	0.250	1.900	24.272	24.359
1	25	20	0.080	0.750	7.767	9.615
1	25	40	0.270	2.360	26.214	30.256
2	25	20	0.100	0.800	9.709	10.256
2	25	40	0.285	2.350	27.670	30.128
3	25	20	0.110	0.790	10.680	10.128
3	25	40	0.290	2.320	28.155	29.744

Table H-2 Averages

Angle of Attack	Speed	Lift (grams)	Drag (grams)
5	20	15.631	5.150
5	40	26.149	17.650
15	20	7.476	7.414
15	40	23.722	24.359
25	20	9.385	10.000
25	40	27.346	30.043

Table H-3 L/D Ratio

Angle of Attack	Speed	L/D Ratio
5	20	3.035
5	40	1.482
15	20	1.008
15	40	0.974
25	20	0.9385
25	40	0.910

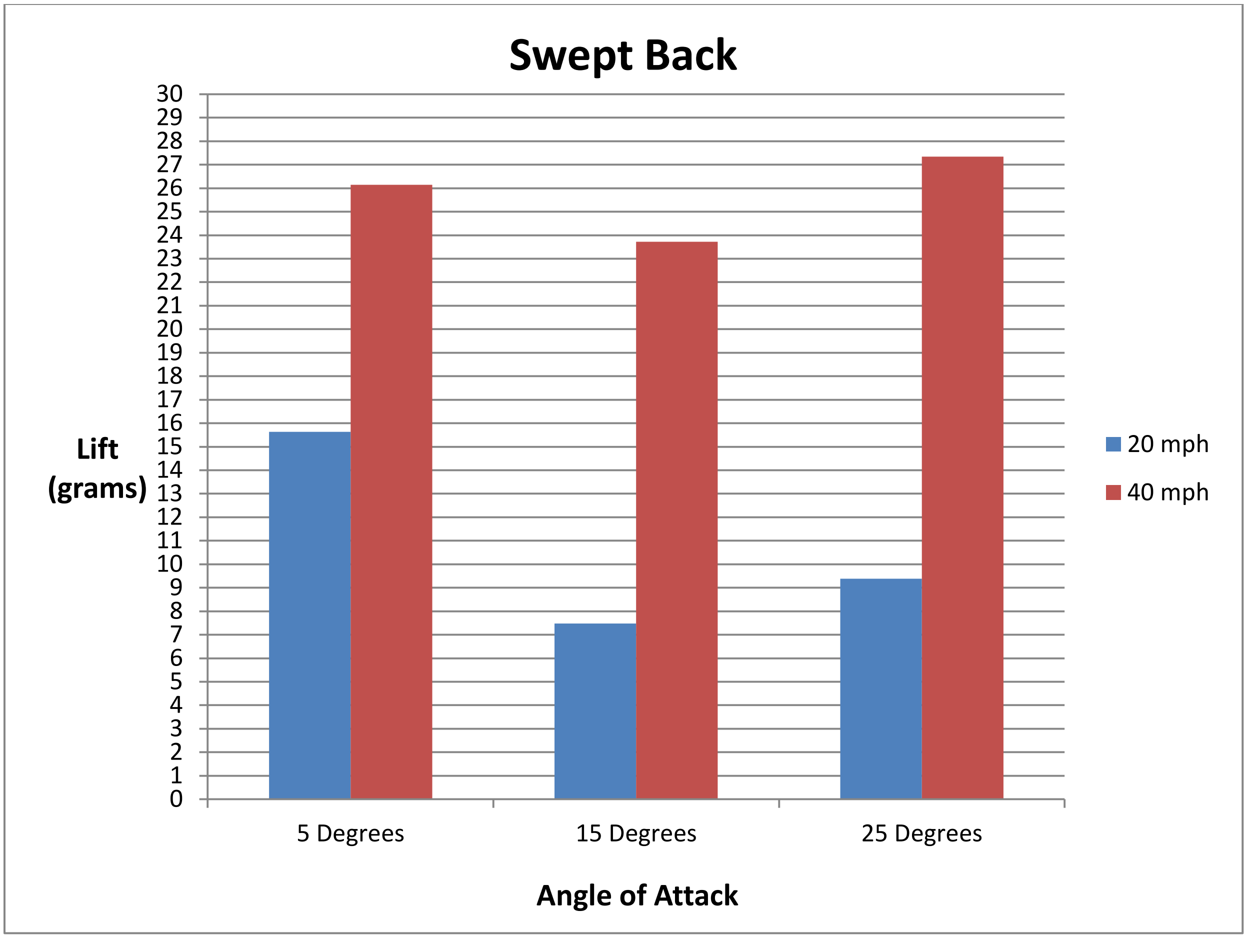


Figure H-3 Swept Back Wing Lift Chart

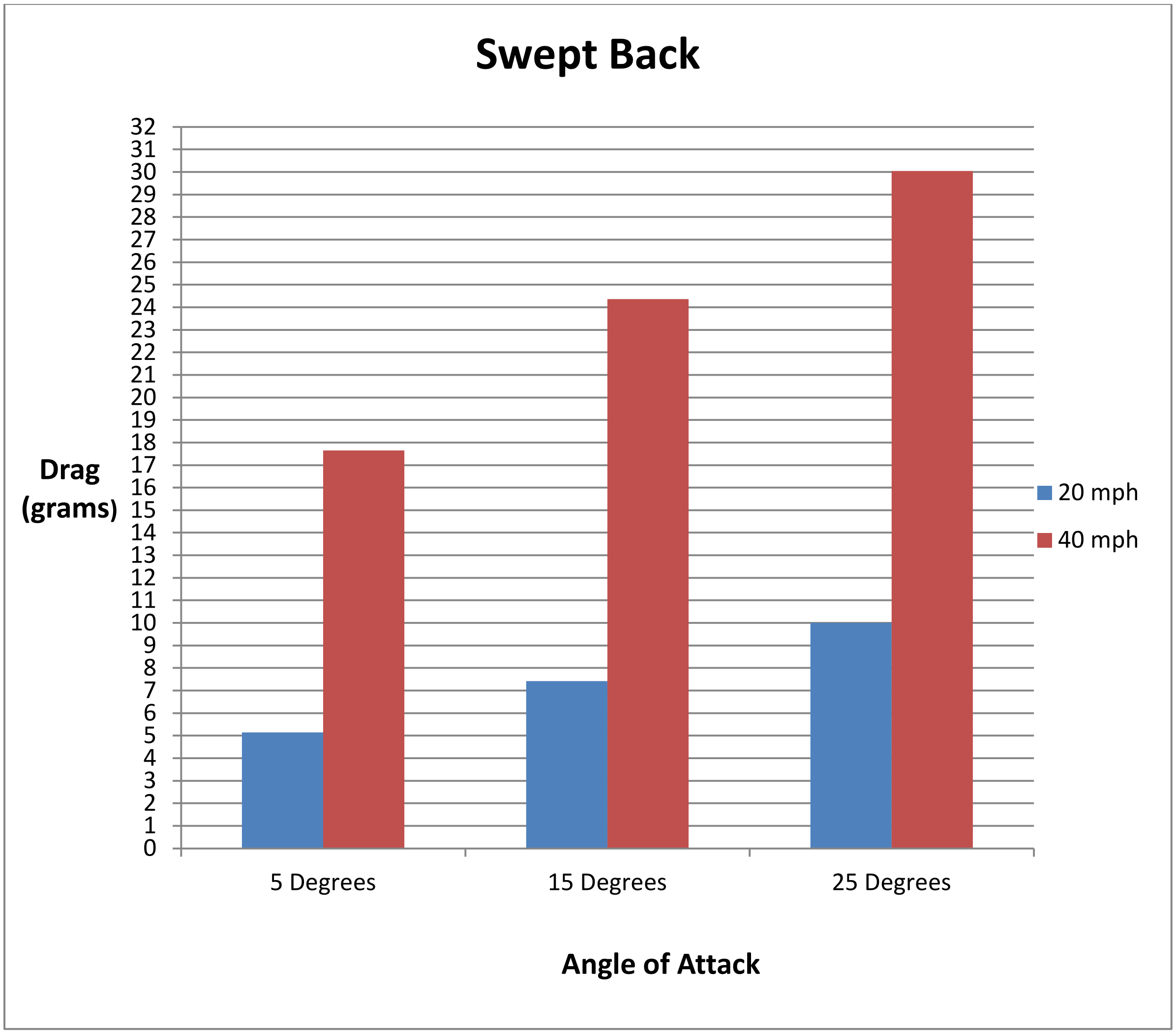


Figure H-4 Swept Back Wing Drag Chart

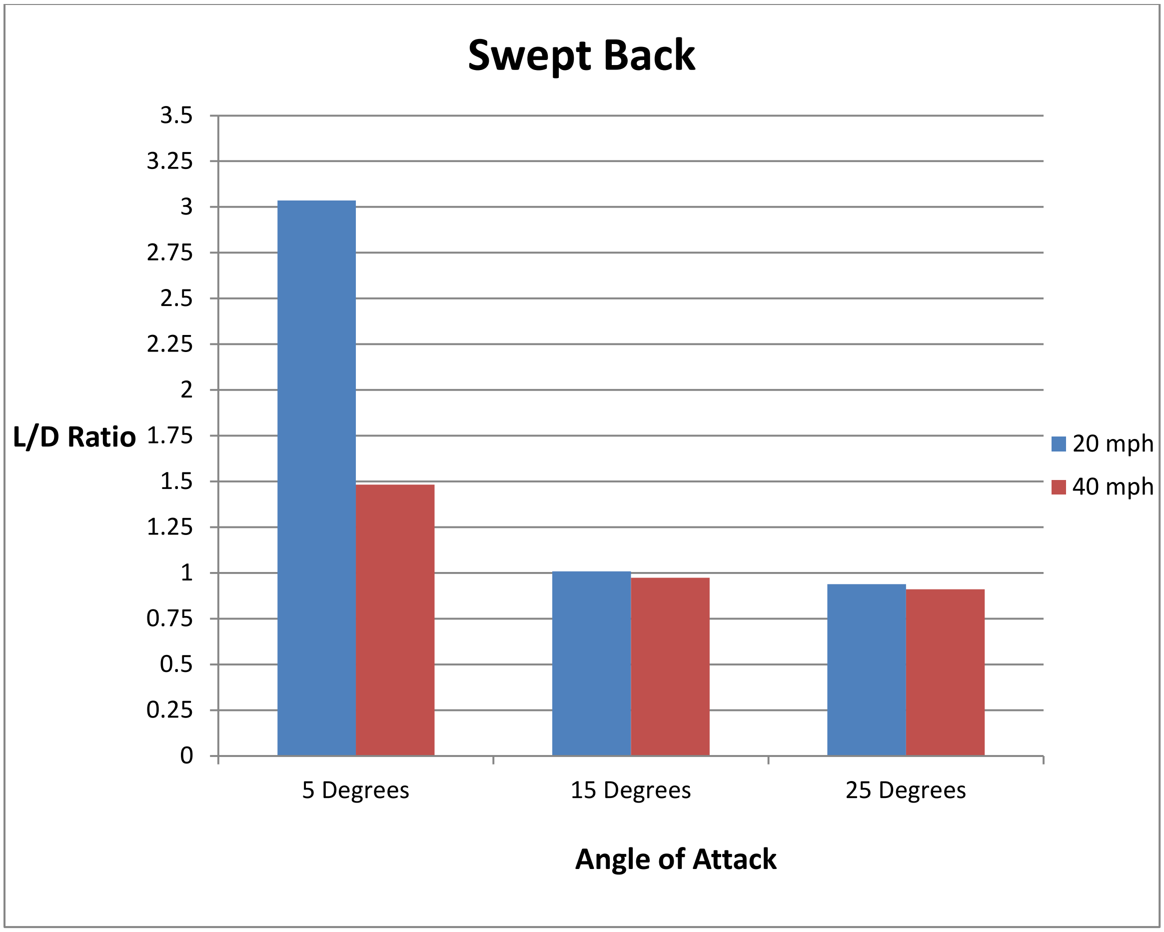


Figure H-5 Swept Back Wing L/D Ratio

Table H-4 Delta Wing Trial Results

Trial	Angle of Attack	Speed (mph)	Lift (volts)	Drag (volts)	Lift (grams)	Drag (grams)
1	5	20	0.080	0.245	7.767	3.141
1	5	40	0.100	0.900	9.709	11.538
2	5	20	0.115	0.300	11.165	3.846
2	5	40	0.135	0.900	13.107	11.538
3	5	20	0.056	0.320	5.437	4.103
3	5	40	0.150	0.890	14.563	11.410
1	15	20	0.010	0.340	0.971	4.359
1	15	40	0.120	1.050	11.650	13.462
2	15	20	0.030	0.360	2.913	4.615
2	15	40	0.145	1.100	14.078	14.103
3	15	20	0.040	0.350	3.883	4.487
3	15	40	0.145	1.100	14.078	14.103
1	25	20	0.015	0.450	1.456	5.769
1	25	40	0.180	1.500	17.476	19.231
2	25	20	0.050	0.480	4.854	6.154
2	25	40	0.180	1.500	17.476	19.231
3	25	20	0.075	0.660	7.282	8.462
3	25	40	0.200	1.500	19.417	19.231

Table H-5 Delta Wing Averages

Angle of Attack	**Speed**	**Lift (grams)**	**Drag (grams)**
5	20	8.123	3.697
5	40	12.460	11.495
15	20	2.589	4.487
15	40	13.269	13.889
25	20	4.531	6.795
25	40	18.123	19.231

Table H-6 Delta Wing L/D/ Ratio Results

Angle of Attack	**Speed**	**L/D Ratio**
5	20	2.197
5	40	1.084
15	20	0.577
15	40	0.955
25	20	0.667
25	40	0.942

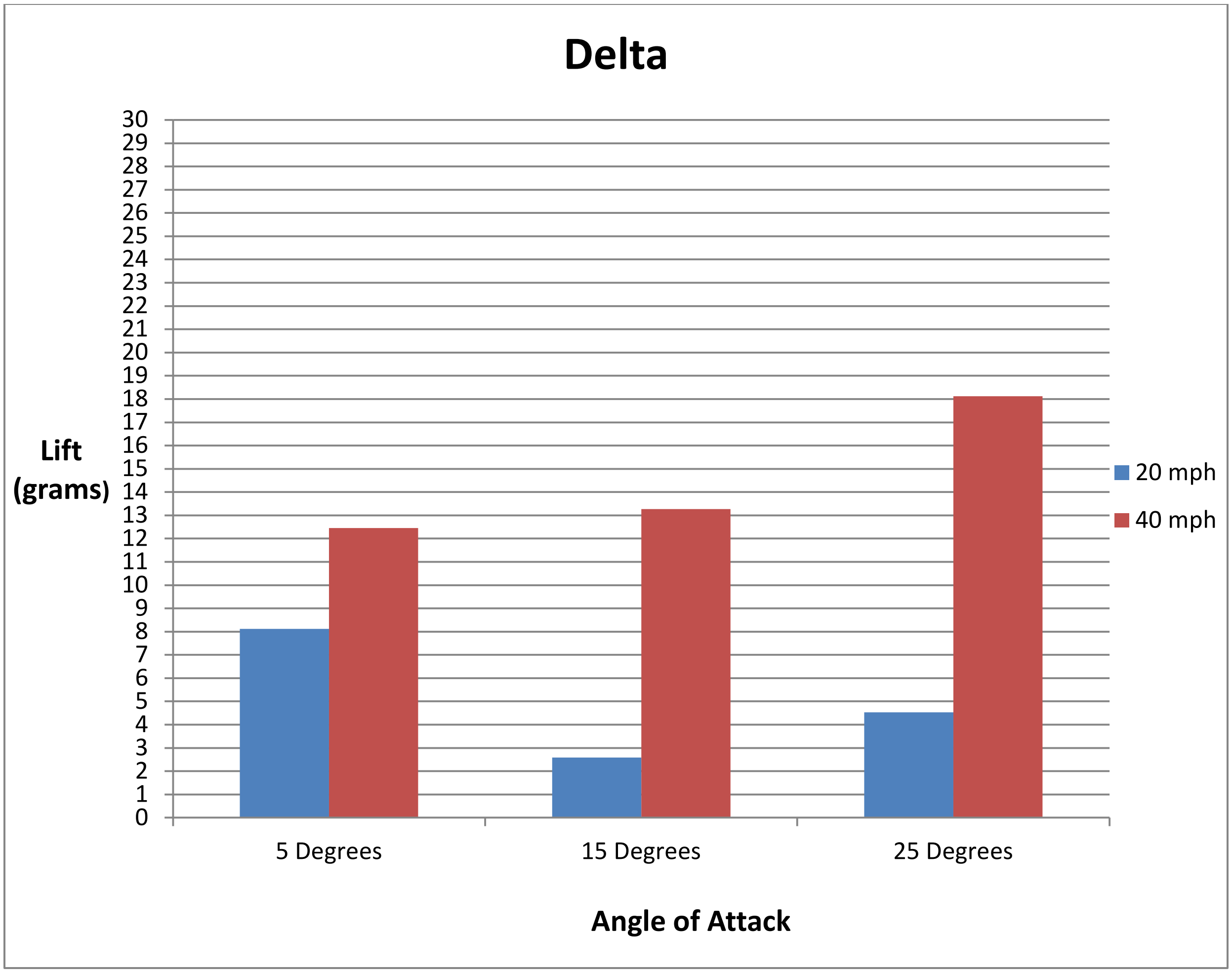


Figure H-6 Delta Wing Lift Chart

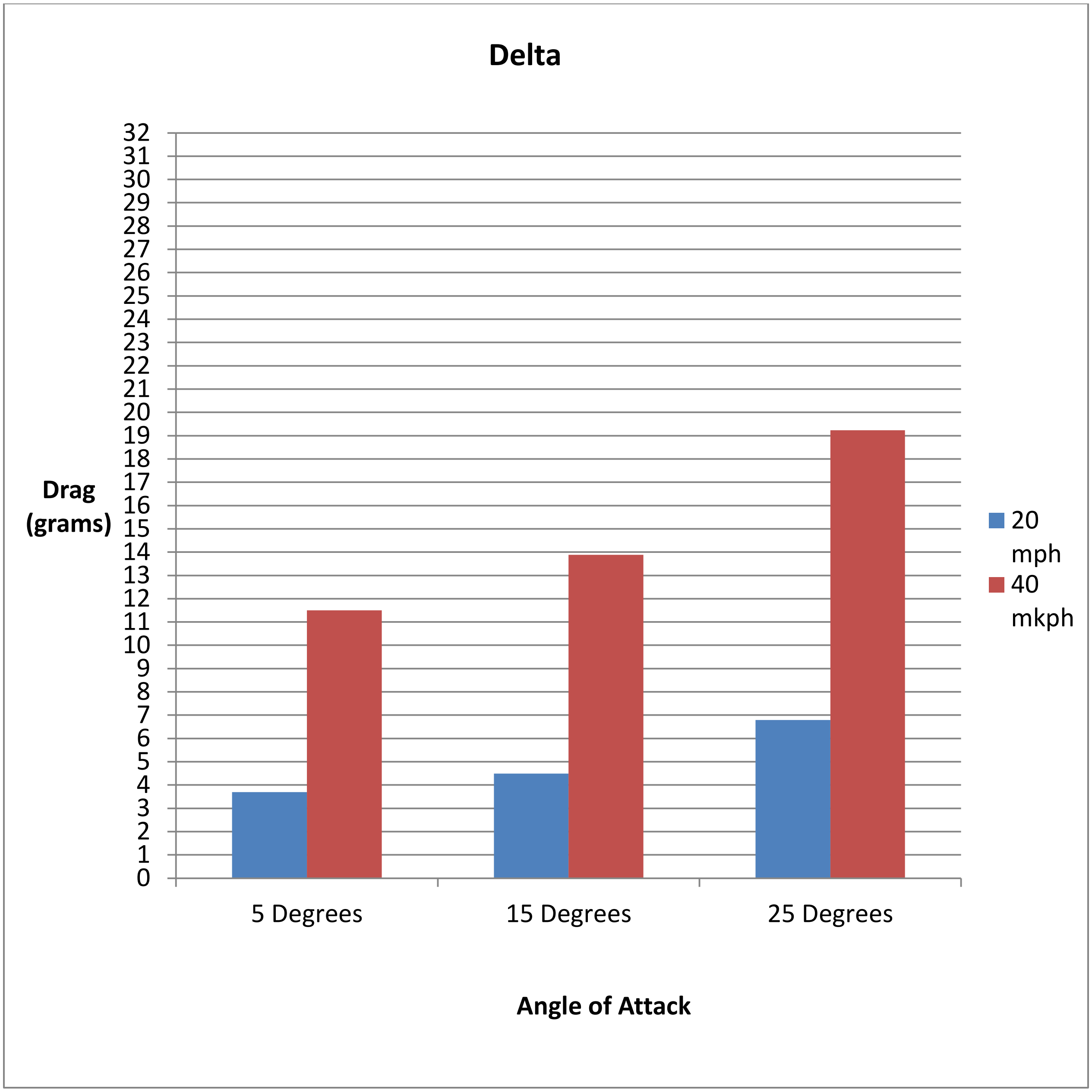


Figure H-7 Delta Wing Drag Chart

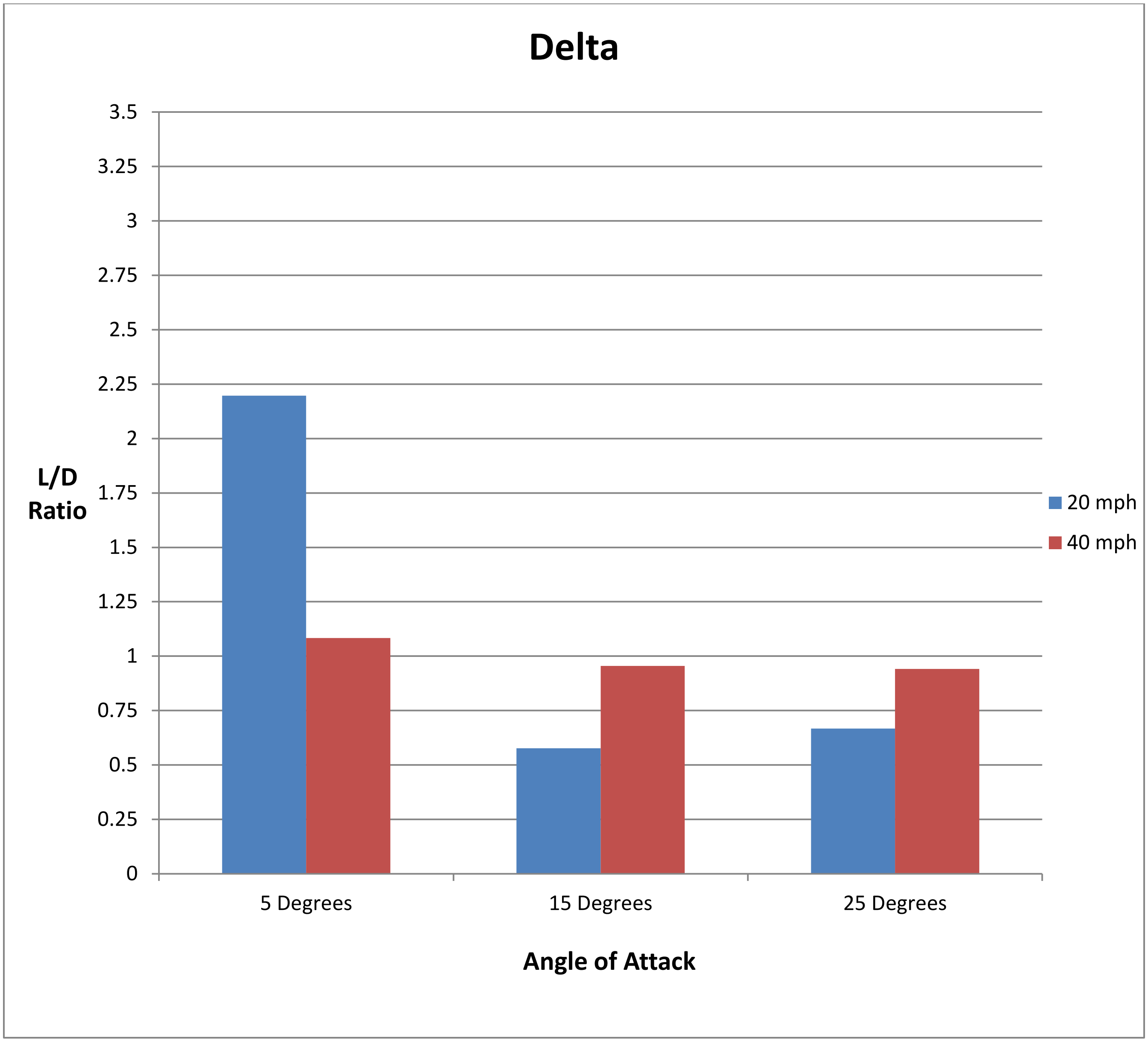


Figure H-8 Delta Wing L/D Ratio Cart

Table H-7 Rectangular Wing Trial Results

Trial	Angle of Attack	Speed (mph)	Lift (volts)	Drag (volts)	Lift (grams)	Drag (grams)
1	5	20	0.050	0.500	4.854	6.410
1	5	40	0.170	1.450	16.505	18.590
2	5	20	0.070	0.480	6.796	6.154
2	5	40	0.200	1.500	19.417	19.231
3	5	20	0.100	0.490	9.709	5.769
3	5	40	0.215	1.500	20.874	18.718
1	15	20	0.025	0.450	2.427	6.090
1	15	40	0.103	1.460	10.000	18.718
2	15	20	0.030	0.475	2.913	6.090
2	15	40	0.130	1.450	12.621	18.590
3	15	20	0.040	0.475	3.883	6.090
3	15	40	0.130	1.500	12.621	18.590
1	25	20	0.100	0.750	9.709	6.090
1	25	40	0.145	2.200	14.078	19.231
2	25	20	0.100	0.720	9.709	9.615
2	25	40	0.130	2.200	12.621	28.205
3	25	20	0.100	0.730	9.709	9.359
3	25	40	0.125	2.190	12.136	28.077

Table H-8 Rectangular Wing Averages

Angle of Attack	Speed	Lift (grams)	Drag (grams)
5	20	7.120	6.282
5	40	18.932	19.017
15	20	3.074	5.983
15	40	11.747	18.846
25	20	9.709	9.402
25	40	12.945	28.162

Table H-9 Rectangle Wing L/D/ Ratio Results

Angle of Attack	Speed	L/D Ratio
5	20	1.133
5	40	0.996
15	20	0.514
15	40	0.623
25	20	1.033
25	40	0.460

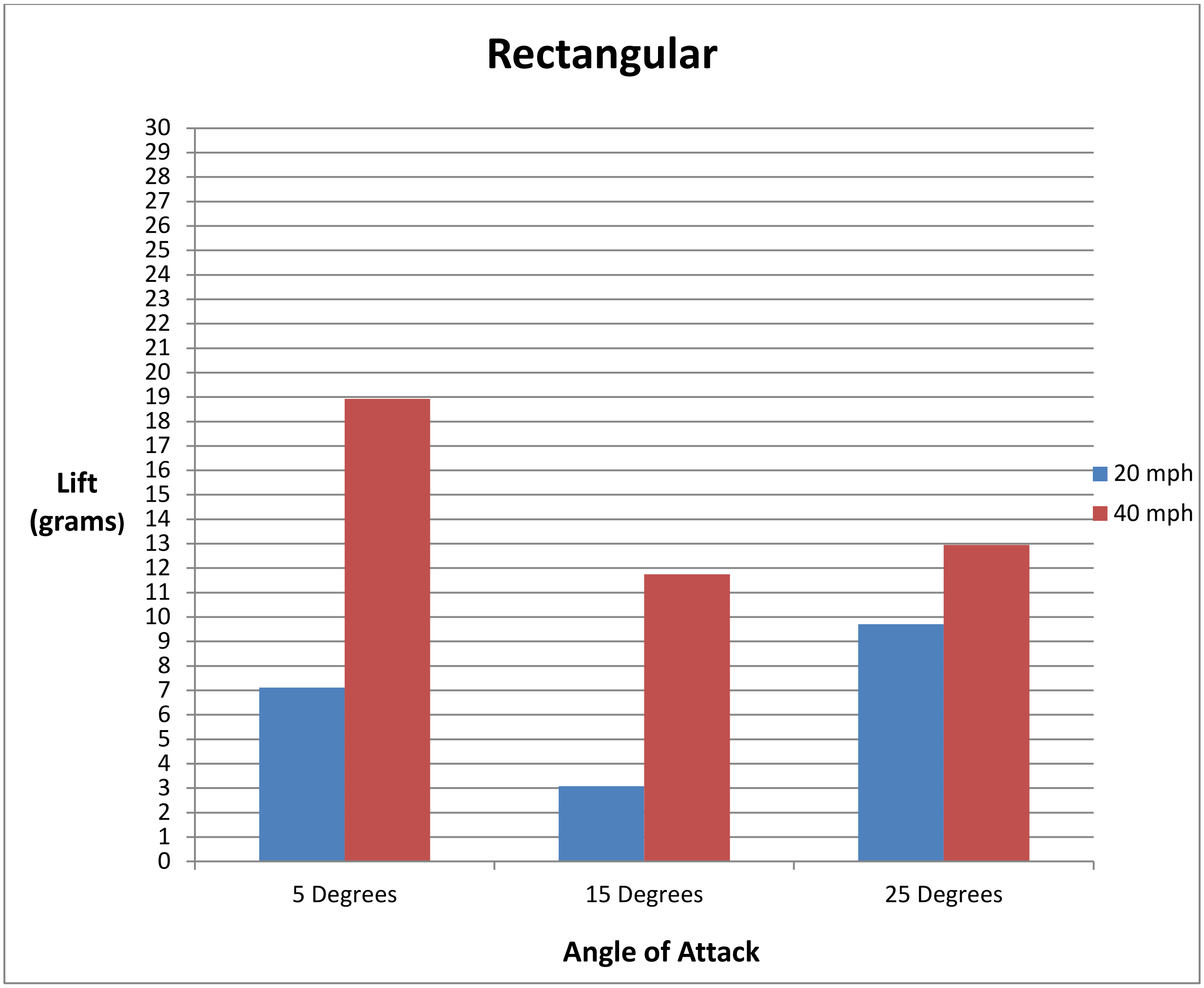


Figure H-9 Rectangular Wing Lift Chart

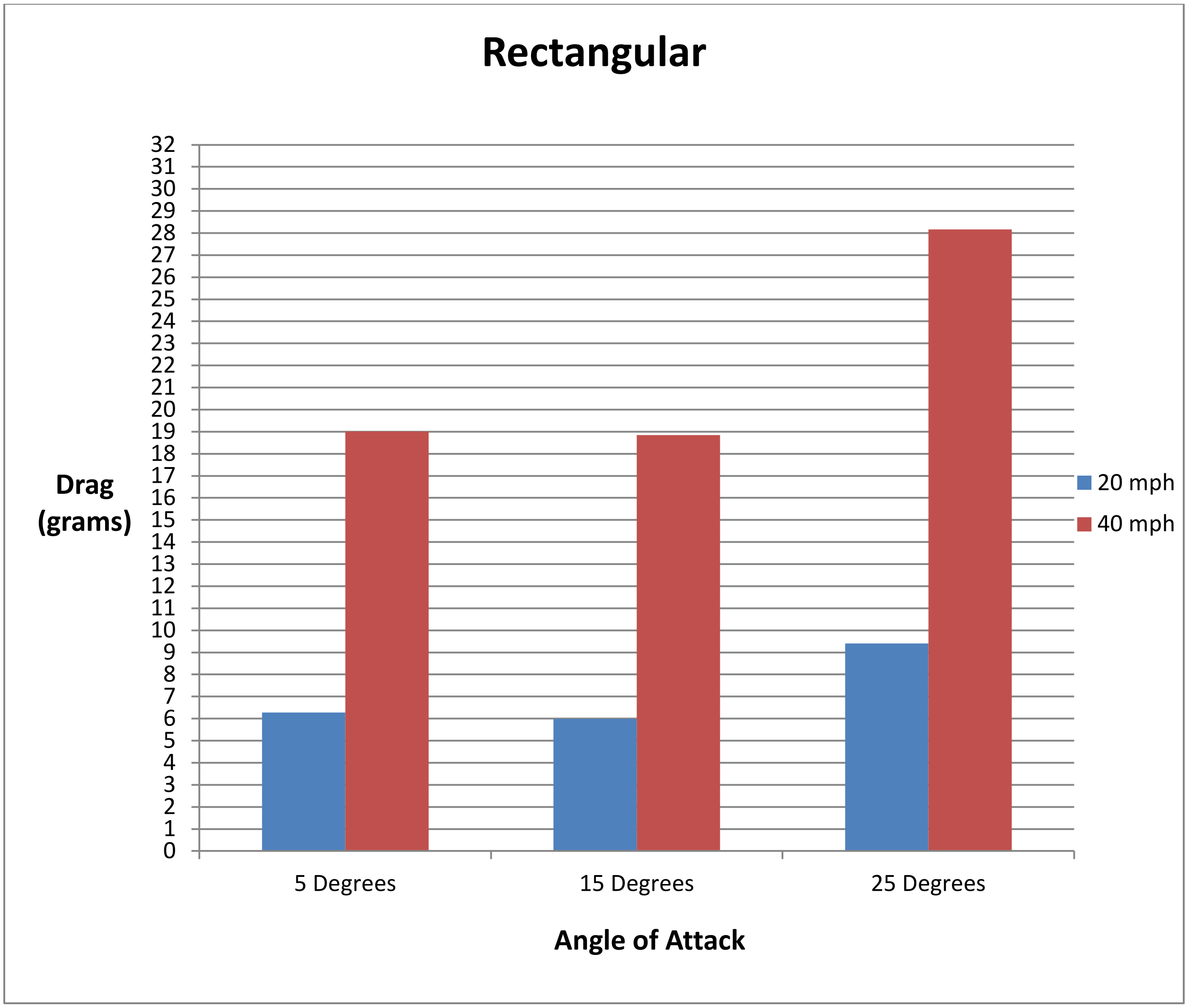


Figure H-10 Rectangular Wing Drag Chart

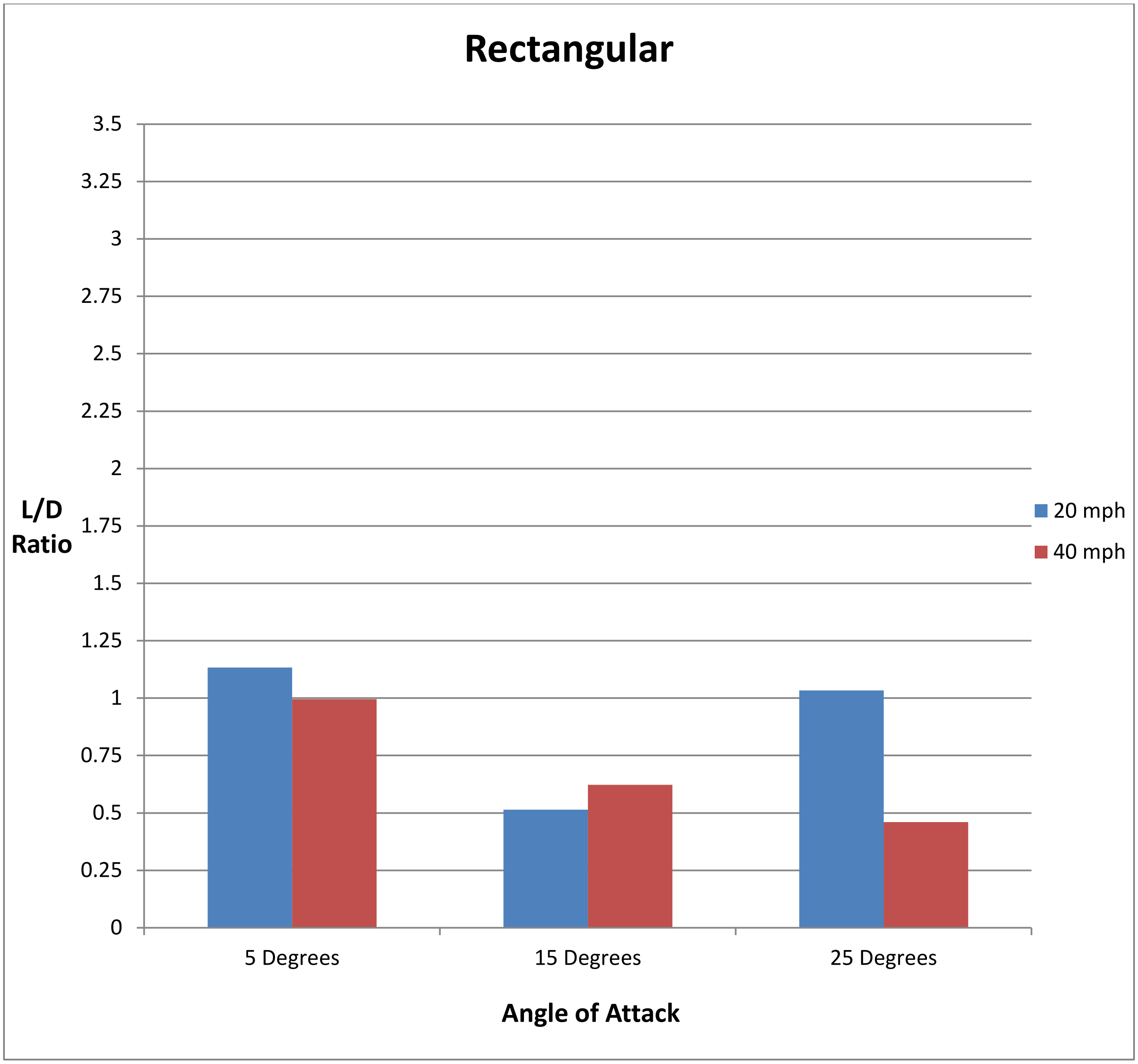


Figure H-11 Rectangular Wing L/D Ratio Chart

Table H-10 Elliptical Trial Results

Trial	Angle of Attack	Speed (mph)	Lift (volts)	Drag (volts)	Lift (grams)	Drag (grams)
1	5	20	0.750	0.450	72.816	5.769
1	5	40	2.800	1.520	271.845	19.487
2	5	20	0.790	0.490	76.699	6.282
2	5	40	2.800	1.500	271.845	19.231
3	5	20	0.760	0.470	73.786	6.026
3	5	40	2.800	1.500	271.845	19.231
1	15	20	0.780	0.600	75.728	7.692
1	15	40	2.600	1.900	252.427	24.359
2	15	20	0.725	0.595	70.388	7.628
2	15	40	2.650	1.959	257.282	25.115
3	15	20	0.780	0.630	75.728	8.077
3	15	40	2.600	2.000	252.427	25.641
1	25	20	0.880	0.740	85.437	9.487
1	25	40	3.150	2.395	305.825	30.705
2	25	20	0.800	0.730	77.670	9.359
2	25	40	3.100	2.340	300.971	30.000
3	25	20	0.920	0.750	89.320	9.615
3	25	40	3.095	2.345	300.485	30.064

Table H-11 Elliptical Averages

Angle of Attack	Speed	Lift (grams)	Drag (grams)
5	20	74.434	6.026
5	40	271.845	19.316
15	20	73.948	7.799
15	40	254.045	25.038
25	20	84.142	9.487
25	40	302.427	30.256

Table H-12 Elliptical L/D Ratio Results

Angle of Attack	Speed	L/D Ratio
5	20	12.352
5	40	14.074
15	20	9.482
15	40	10.146
25	20	8.869
25	40	9.996

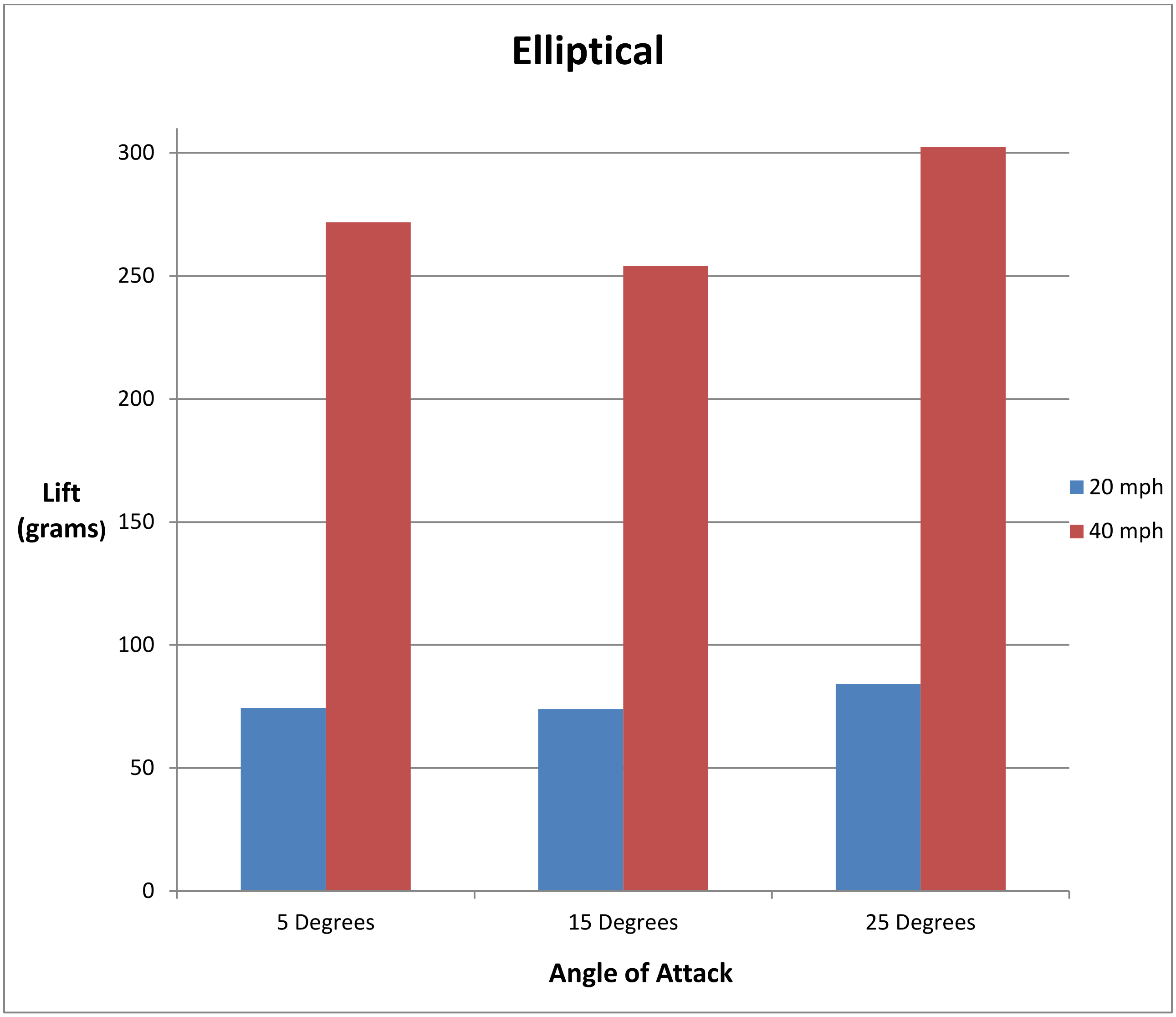


Figure H-12 Elliptical Wing Lift Chart

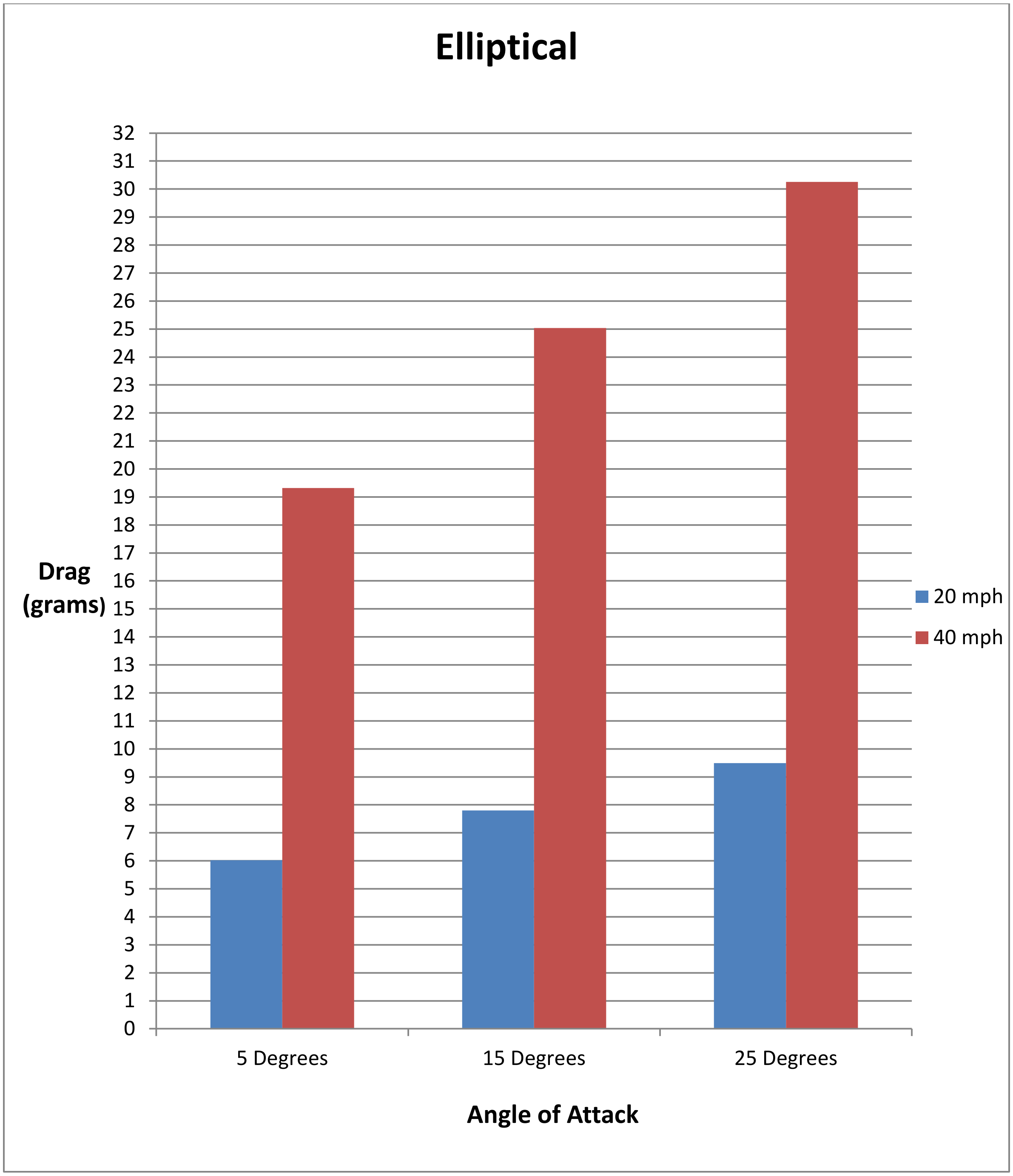


Figure H-13 Elliptical Wing Drag Chart

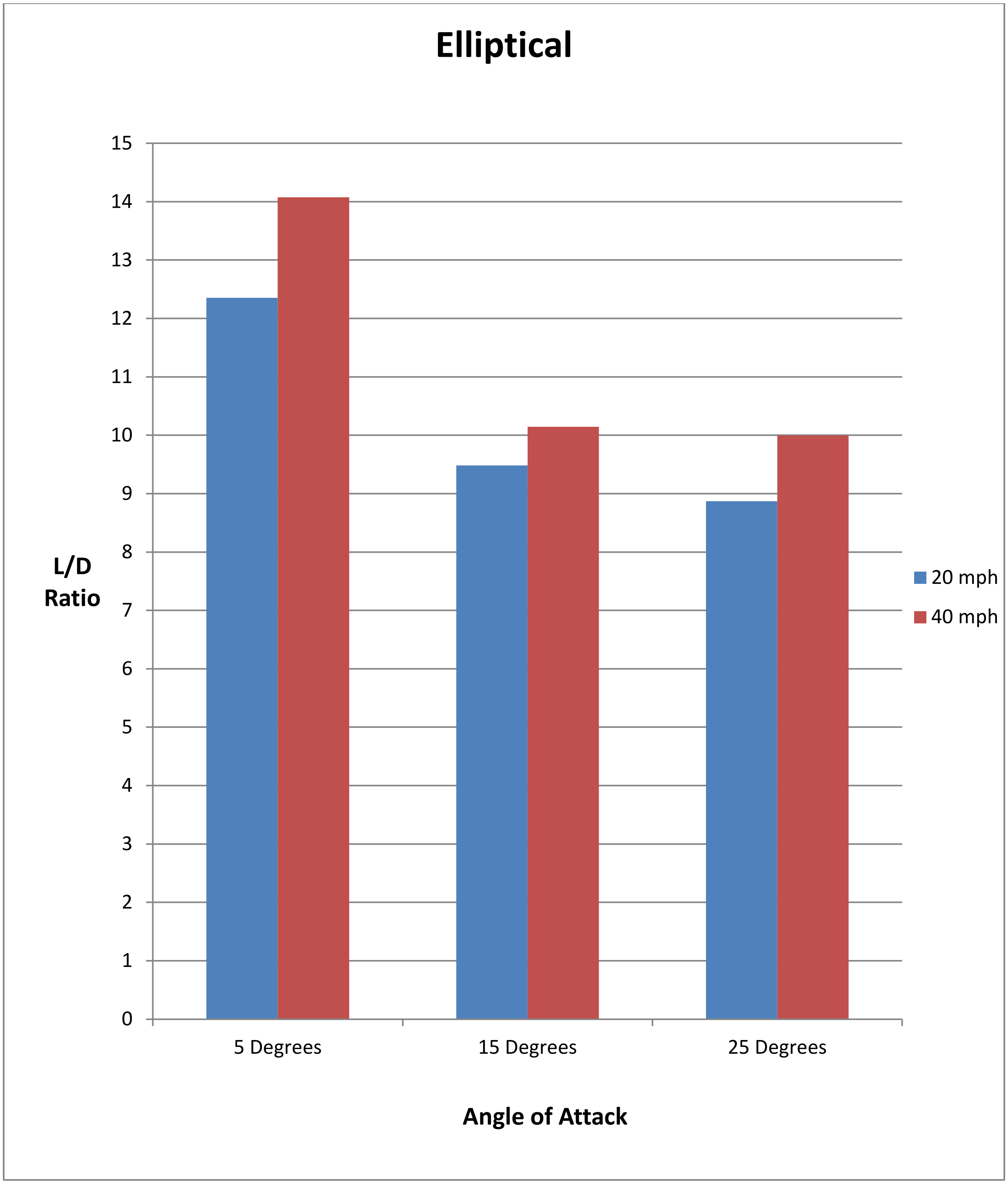


Figure H-14 Elliptical Wing L/D Ratio Chart

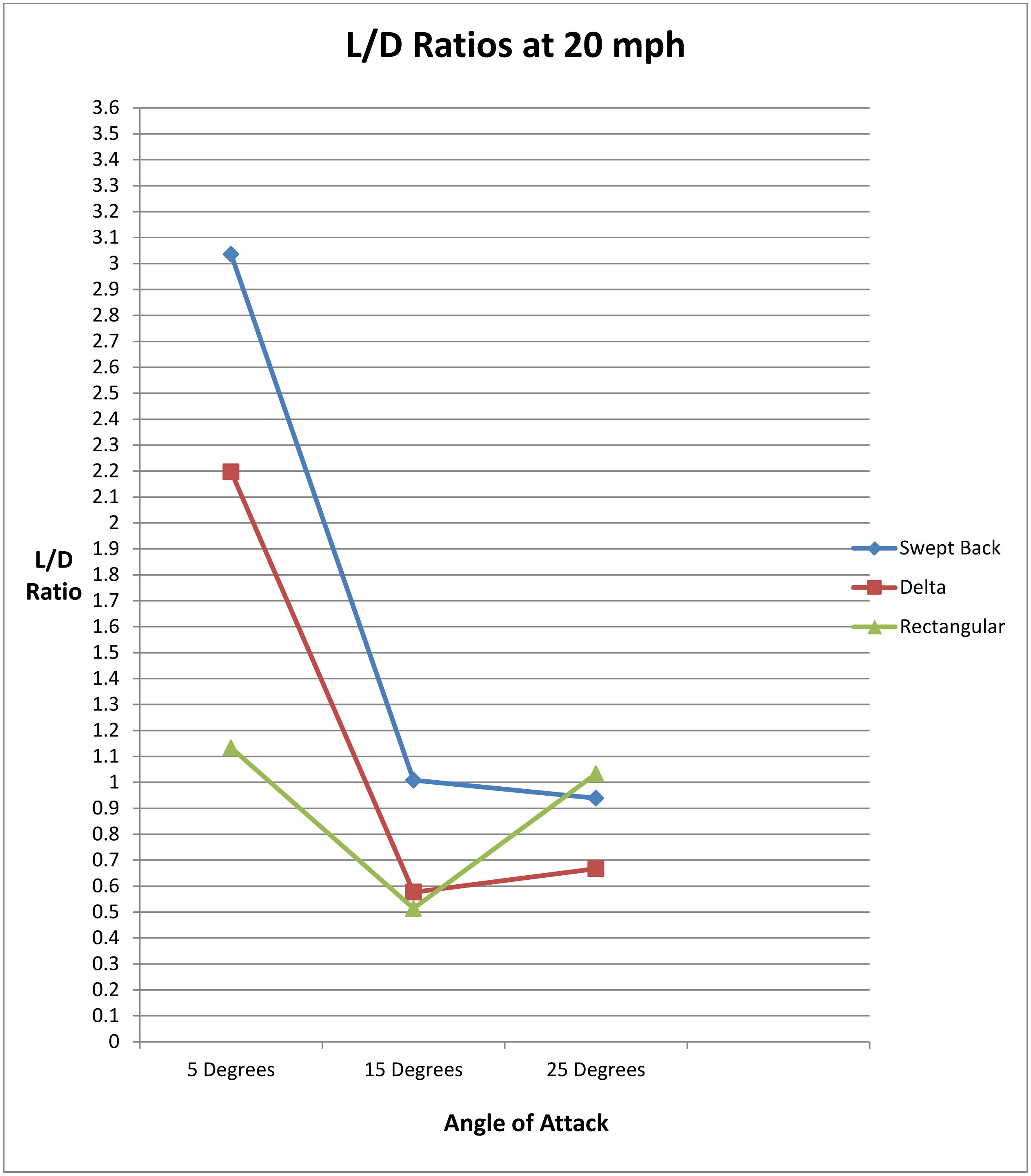


Figure H-15 Elliptical Wing L/D Ratios at 20 mph

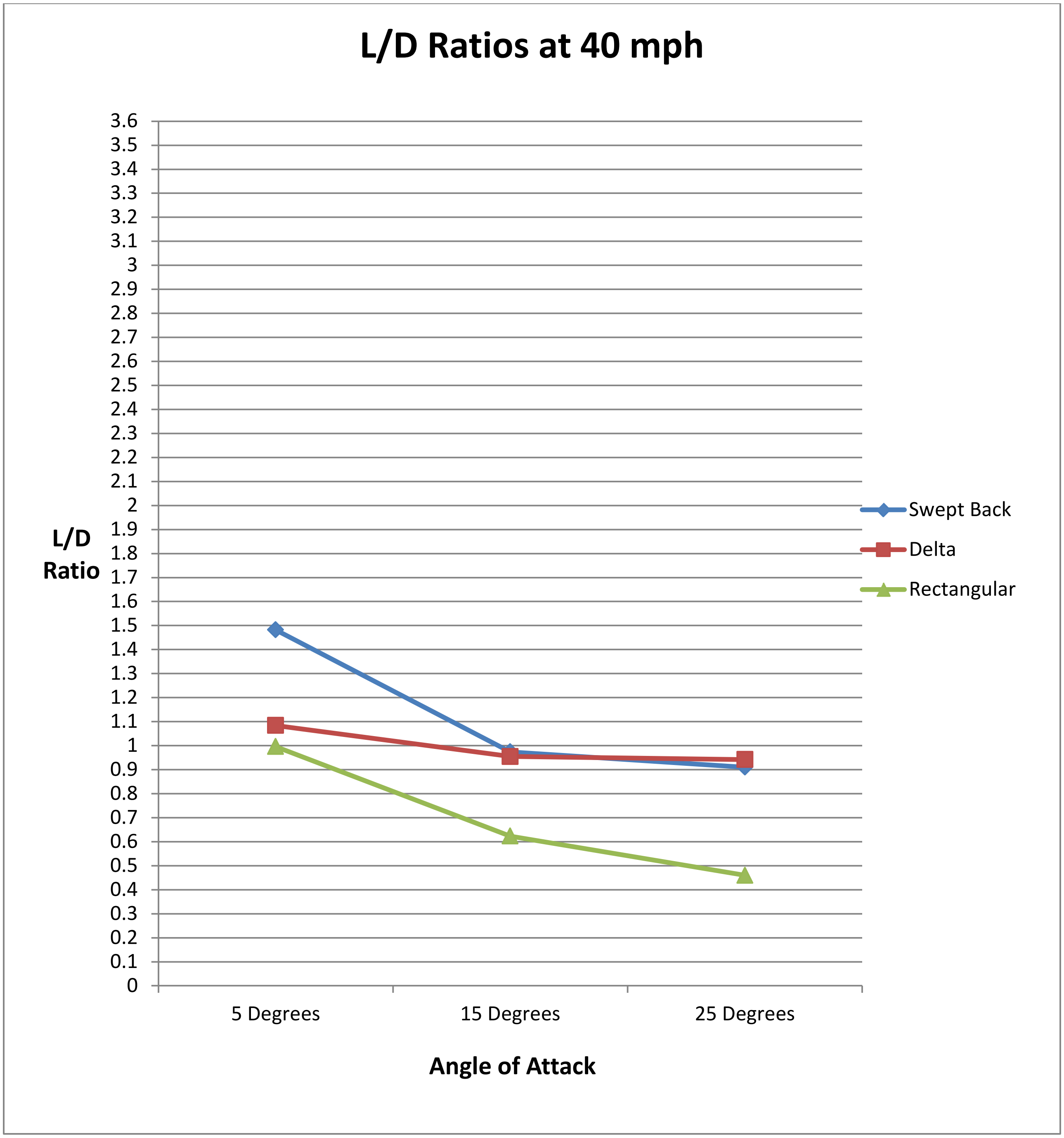


Figure H-16 Elliptical Wing L/D Ratios at 40 mph

H1.9 Discussion

The elliptical shaped wing data that was read is inaccurate because while taking the rectangular shaped wing out of the wind tunnel it jammed and this caused a dramatic change in the way it read because of the very sensitive strain gauge it uses to measure lift and drag. As a result, its data won't be included in the discussion or the line graphs that compares all the wings at once.

The swept back shaped wing produced high lift at full speed and lower lift at half speed as seen in figure H-3 so it gets more lift at fast speeds. It produced low drag at half speed and at full speed it produced higher drag, especially as the angle of attack increased as shown in figure H-4. The swept back wing produced lower drag at a lower angle of attack and that's why at a 5 degree angle of attack it has the highest lift to drag ratio as seen in figure H-15 and H-16.

The delta shaped wing produced lower lift than the drag at a 15 and 25 degree angle of attack and caused a lift to drag ratio less than 1 but at a 5 degree angle of attack its lift to drag ratio was more than one as seen in Table H-9. The delta shaped wing is more efficient at a lower angle of attack just like the swept back shaped wing, but it's L/D ratio is lower than the swept back shaped wing as seen in figure H-15 and H-16.

The rectangular shaped wing produced lower drag than lift at: a 15 degree angle of attack for full and half speed, full speed for a 5 degree angle of attack, and full speed for a 25 degree angle of attack but at half speed for a 5 degree angle of attack and 25 angle of attack there was more lift than drag as seen in Table H-8. Figure H-15 and H-16 indicates the rectangular wing has the worst efficiency between the delta shaped wing and swept back shaped wing.

H1.10 Conclusion

The hypothesis was correct. The swept back shaped wing had the greatest L/D ratio because it produced more lift and lower drag than the other wing shapes due to its shape which has lateral stability and little induced drag because of its wing tapers.

H1.11 Next Steps

I plan on trying to readjusting the wind tunnel and test the elliptical wing again. Also, if I were to do a project like this next year, I'm going to find a larger scale wind tunnel to use and test actual airplane models with these wing shapes on them.

H1.12 Acknowledgments

Dr. Anwar Ahmed
Mr. Hank Baust
Mr. Henry Noble
Mrs. Glenda Konechney

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H2. Induced Drag Coefficient by Mitchell Cowan, Grade 12

H2.1 Abstract

This project is about induced drag. When testing swept back, delta, and rectangular wing designs at 5°, 15°, and 25° angles of attack, and wind speeds going 40mph and 20mph in a wind-tunnel, which will produce the least amount of induced drag?

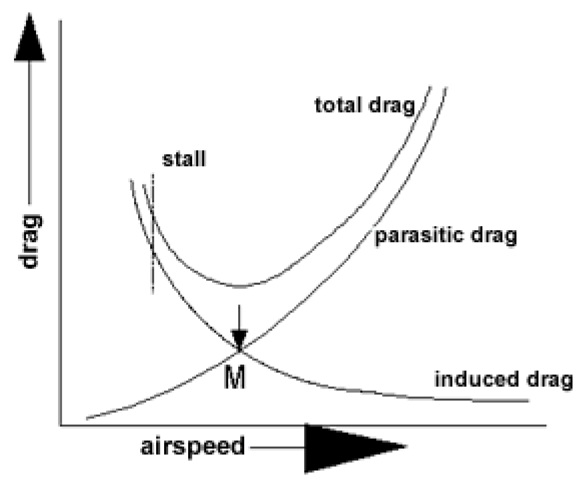
Induced drag slows an aircraft down and increases the risk of stall; stall is the turbulence that overcomes the airfoil which causes the aircraft to lose lift and drop airspeed which results in poor performance and deadly accidents.

The hypothesis states that "If delta, swept-back, and rectangular shaped wings are tested in a wind-tunnel at 20 mph and 40 mph and 5°, 15° and 25° angle of attack, then the delta wing will have the least amount of induced drag because the 90° trailing edge of the delta produces less turbulence increasing the speed compared to the swept-back's open wing which produces a lot of turbulence along the fuselage creating drag, the rectangular wing has a straight wing configuration which increases drag due to its 90° leading edge and 90° trailing edge."

In result, the hypothesis was correct; the delta wing had the least amount of induced drag compared to the swept-back and rectangular wing at 40mph and 5° angle of attack. The independent variables were wind-speed, wing size, angle of attack, and wings, the dependent variables were the amount of lift produced, coefficient of lift calculated and the induced drag coefficient calculated. The control was wing area.

H2.2 Hypothesis

If delta, swept-back, and rectangular shaped wings are tested in a wind-tunnel at 20 mph and 40 mph and 5°, 15° and 25° angle of attack, then the delta wing will have the least amount of induced drag because the 90° trailing edge of the delta produces less turbulence increasing the speed compared to the swept-back's open wing which produces a lot of turbulence along the fuselage creating drag, the rectangular wing has a straight wing configuration which increases drag due to its 90° leading edge and 90° trailing edge.



(Photo/Graph from: http://www.pilotfriend.com)

Figure H-17 Drags v. Airspeed

High Angle of Attack = High lift = Low speed = More induced drag
Low Angle of Attack = Low lift = High speed = Less induced drag

Smaller angle of attack will create more speed but reduce the amount of lift; the decreased amount of lift, smaller angle of attack, and high speed is the reason why induce drag decrease will decrease with more airspeed.

"The first thing that common sense tells us is that the pressure waves described above will spread out at the speed of sound. So we can predict that induced drag must be a phenomenon of sub-sonic flight. We can say that induced drag is only a factor if the airplane flies slower than the speed of sound (sub-sonic flight.)."

H2.3 Materials

1. Foam board
2. Calculator
3. Projector
4. Knife
5. Wind-Tunnel
6. Laptop
7. Ruler
8. Pencil

H2.4 Methods

1) Prep the wind-tunnel; make sure readings are set to "0".
2) Gather foam boards to make wing shapes.
3) Sketch wing design; measure surface area.
4) Cut out wing design with knife.
5) Place wing configuration into the wind-tunnel (Test at 5°, 15°, and 25° degrees Angle of attack).
6) Test wings going full speed 40mph in the wind tunnel, then test going half speed 20mph.
7) Record data in log book.
8) Calculate lift coefficient.
9) Substitute variables with recorded data. (Lift coefficient, aspect ratio, airspeed(velocity), and efficiency factor).
10) Calculate induced drag coefficient.

H2.5 Background Research About Drag

H2.5.1 Drag

"Drag is just the air 'pulling' on the aircraft"

Drag is the opposite reaction to thrust; drag is the aerodynamic force that opposes an aircraft motion through the air. Drag only occurs when there is fluid present and a solid body is in contact, thus, if there is no fluid, there is no drag; fluid is also the air, this also acts throughout the whole body. Distribution of airflow by the wing, rotor, fuselage, and other protruding objects; this happens to the whole airplane. Drag opposes thrust and acts reward parallel to relative wind. Drag slows an aircraft down, which in fact kills speed.

More drag = Less speed
Less drag = More speed
Big area = More drag

H2.5.2 Induced Drag

Induced drag is force occurred when a moving object redirects laminar airflow coming towards a wing causing a “vortex”. This type of drag occurs in airplanes due to wings or lifting body redirecting air to cause lift and also in cars with airfoil wings that redirect air to cause a down force. Induced drag increases as angle of attack increases. Induced drag is not a friction force; it is the vortex of wing over the wing tips. Induced drag which arises from the need to maintain lift tends to be greater at lower speeds where a high angle of attack is required. However, as speed increases, the induced drag decreases.

Induced drag is a consequence on lift, produced by wings. Flowing air above the wing tends to flow inwards because the deceased pressure over the top surface is less than the pressure outside the wing tip. At the bottom of the wing air flows outwards because the pressure below the wing is greater than that outside the wing tip. High aspect ratio wings are better than low aspect ratio wings because the proportion of air which moves in this way is reduced and then generates more lift.

Induced drag and its wing tip vortices are a direct consequence of the creation of lift by the wing. Since the Coefficient of Lift is large when the Angle of Attack is large, induced drag is inversely proportional to the square of the speed whereas all other drag is directly proportional to the square of the speed. The effect of this is that induced drag is relatively unimportant at high speed in the cruise and descent where it probably represents less than 10% of total drag. In the climb, it is more important representing at least 20% of total drag. At slow speeds just after take-off and in the initial climb, it is of maximum importance and may produce as much as 70% of total drag. Finally, when looking at the potential strength of wing tip vortices, all this theory on induced drag must be moderated by the effect of aircraft weight. Induced drag will always increase with aircraft weight. (SKYbrary.com, Par. 6)

H2.5.3 Form Drag

“It’s the objects reason for this type of drag” Form drag is the flow that separates near the trailing edge, due to the shape of the body; this causes low pressures near the trailing edge, pulling the object back. As air flows around a body, the local velocity and pressure are changed. Since pressure is a measure of the momentum of the gas molecules and a change in momentum produces a force, a varying pressure distribution will produce a force on the body. Also known as pressure or profile drag.

H2.5.4 Wave Drag

Wave drag is when shock waves form over the airfoil, converting energy of the flow into heat causing drag; most high speed aircrafts create a “sonic boom” due to the aircraft going faster than the speed of sound, this is the visible wave drag. The angle of attack of the object to the low also affects the amount of drag generated by a given shaped object. If the object move through the air at speeds near the speed of sound, shock waves are formed on the object which create an additional drag component called wave drag.

Wings on faster aircrafts = More wave drag

H2.5.5 Skin Friction Drag

Skin friction Drag is the drag force that makes the air flow "stick" to the wings and the aircraft. The interaction between a solid and a gas: the magnitude of the skin friction depends on properties of both solid and gas. It is directly proportional to the area of the surface in contact with the fluid and increases with square of the velocity. Friction drag is created in the boundary later due to the viscosity of the air and the resulting friction against the surface of the aircraft. Turbulent flow creates more friction drag than laminar flow due to its greater interaction with the surface of the airplane.

Large surface area = More friction drag

H2.6 Airfoils

H2.6.1 Swept-back

Swept-back wings are wings that are angled back from the center of the aircraft. This airfoil is used on high speed transonic aircrafts and some commercial airliners. This wing creates lift from shock waves. Swept-back wings have low aspect ratio which causes air to leak around the wing-tips reducing their effectiveness.

Area: Wing area = ½ height($base_1$ + $base_2$)

F-86 Saber--Top speed: 650 mph (Mach 0.9)

(Photo from: http://www.warrelics.eu/forum/military_photos/aircraft/416968d1351574404-mig-15-korean-combat-f86-sabre.jpg)

Figure H-18 Swept Back Wings of an F-86 Saber

The F-86 Sabre as seen in the picture above is a swept-back wing design fighter jet that is transonic (Close to supersonic speed) used during the Korean War. This aircraft was retired from combat but there are some aircrafts that still uses the swept-back design: For example, the B-52 Bomber and some commercial airliners like Boeing.

H2.6.2 Delta Wings

The delta wing came from the theory of rockets from German engineers in the 1940s. This wing is similar to the swept-back wing but full figured. These wings were also used on supersonic aircrafts and NASA rockets to increase the speed of aircrafts to go faster than the speed of sound (Mach > 1).

Area: Wing area = ½(Base x Height)

F-106 Delta Dart
Top speed: 1,525 mph (Mach 2.31)

(Photo from: http://www.strategic-air-command.com/aircraft/fighter/images/f106_delta_dart.jpg)
Figure H-19 Delta Wing Shown on F-106 Delta Dart

In the picture above is the F-106 Delta dart created in the 1959 by the United States Air Force; the F-106 is a bomber interceptor used to protect from bombings and other enemy aircrafts. Modern planes that uses delta wings are NASA's space shuttles and

H2.6.3 Rectangular Wings

Rectangular wings are perpendicular to the fuselage (body) of the aircraft. This wing is not ideal for supersonic aircrafts; rectangular wings are used for personal aircrafts with reasonable speed. Rectangular wings have a great amount of lift but have a great amount of drag due to its aspect ratio. **Area:** A = Base x Height

Piper PA-28-161 Warrior II
Top-speed: 145mph (Mach 0.2)

(Photo from: http://flyojhs.weebly.com)
Figure H-20 Rectangular wing Shown on Piper PA-28-161 Warrior II

This aircraft shown above is a personal aircraft with a rectangular wing configuration; this aircraft was introduced in the 1970's from the PA-28 Cherokee family of aircrafts.

H2.7 Equations

H2.7.1 Induced Drag Coefficient Equation:

$$Cd_i = CL / \pi \text{ x } AR \text{ x } e$$

Cd_i – Coefficient of Induced drag
CL – Coefficient of Lift
pi – 3.14 (pie)
AR – Aspect Ratio (Mean chord / Length) Ratio of length and chord line.
e – Efficiency factor

H2.7.2 Lift Coefficient Equation

$$CL = 2L / \rho \text{ x } V^2 \text{ x } A$$

CL – Coefficient of Lift
L – Lift force
ρ – Density (Air quality)
V – Velocity (squared)
A – Area of platform

H2.8 How an Aircraft Flies

Airfoils create lift from pressure differences from the top and bottom of the airfoil. There is lower air pressure on the top of the aircraft, and higher air pressure on the bottom of the airfoil causing the wing to go up.

H2.8.1 Thrust

Thrust is the forward produced by the power plant/propeller or rotor. It opposes or overcomes the force of drag. As a general rule, it acts parallel to the longitudinal axis.

Thrust = Drag (Opposite reaction)

H2.8.2 Weight

Weight is the combined load of the aircraft itself, the crew, fuel, and the cargo or baggage. Weight pulls the aircraft downward because of the force of gravity. It opposes lift and acts vertically downward through the aircrafts center of gravity.

Lift = Weight (Opposite reaction)

H2.8.3 Lift

Lift opposes the downward force of weight; lift is produced by the dynamic effect of the air acting on the airfoil, and acts perpendicular to the flight through the center of lift. Lift is produced when a mass of air is deflected and it always acts perpendicular to the result relative wind.

Factors of “Lift”:

- Angle of Attack (AoA)
- Total area of the segment or airfoil.
- Density of the air.
- Speed of the airflow.

In lift, the flow meeting the leading edge of the object is forced to split over and under the object causes an area of low pressure to form behind the leading edge on the upper surface of the object. Due to this pressure gradient and the viscosity of the fluid, the flow over the object is accelerated down along the upper surface of the object. At the same time, the flow forced under

the object is rapidly slowed or stagnated causing an area of high pressure. This also causes the flow to accelerate along the upper surface of the object. The two sections of the fluid each leave the trailing edge of the object with a downward component of momentum, producing lift.
Air Pressure is the force exerted by air, whether compressed or unconfined, on any surface in contact with it in this case, a wing.

H2.8.4 Angle of Attack (AoA)

Angle of attack is the angle between the chord line and the flight direction. Too much angle of attack will create stall and to little angle will not create much lift. The angle of attack or "AoA" is the angle at which the airflow.
"Positive angle of attack produces positive lift"
"Zero angle of attack produces zero lift" Unless cambered or non-symmetrical.
"Negative angle of attack produces negative lift"

H2.8.5 Stall

When there is too much angle of attack, known as the "critical angle of attack" then the aircraft "stalls". Stall is the reduction in lift coefficient generated by a foil as angle of attack increase; when critical angle of attack is exceeded, approximately above 15°. During stall, turbulence overcomes the airfoil which causes the aircraft to lose lift and drop airspeed. Stall is never good in an aircraft because they result in loss of control and eventually died, but some stalls are recoverable.

H2.8.6 Upwash

Upwash is the relative laminar airflow blowing from underneath the wing which at the leading edge moves upwards; the flow of air directly ahead of the leading edge of a moving airfoil coming over the low pressure region of the wing to the trailing edge.

H2.8.7 Downwash

Downwash is the air forced down by the aerodynamic action of a wing; part of producing lift.

H2.8.8 Newtons' Law's

1. "Every object will remain at rest or in uniform motion in a straight line unless compelled to change its state by the action of an external force."
2. "Force is equal to the change in momentum (mV) per change in time. For a constant mass, force equals mas times acceleration F = ma."
3. "For every action, there is an equal and opposite re-action."

When thrust and drag are equal, aircraft holds constant airspeed, when thrust is increased, aircraft accelerates and airspeed increases. Drag depends on airspeed – drag increases when drag is again equal to thrust; the aircraft no longer accelerates but holds a new, higher and constant airspeed.

H2.8.9 Bernoulli's principle

Bernoulli's principle is the physical principle formulated by Daniel Bernoulli that states that as the speed of a moving fluid (liquid or gas) increases, the pressure within the fluid decreases.

H2.9 Parts of an Airfoil

Chord Line: The distance from the leading edge to the trailing edge.
Leading Edge: The front of the wing is called the trailing edge.
Trailing Edge: The back of the wing.
Span: The distance from one wing tip to the other.

H2.10 Wind-Tunnel

Wind-tunnels are large tubes with air moving inside. The tunnels are used to copy the actions of an object in flight. Researchers use wind-tunnels to learn more about how an aircraft will fly. Wind-tunnels use powerful high-speed fans that pull air through the tube and exits through the fan from the tube. The test subject (i.e., small vehicle, aircraft, wing etc...) is placed into the container or tunnel area secured tightly to be tested by the flow of air. The air moving around the still object shows what would happen if the object were moving through the air.

The forces that act on an aircraft are the same whether the aircraft is moving through the air or the air moving past a stationary aircraft. To obtain meaningful data, the researcher must insure that the airflow in the wind-tunnel is very similar to that found in flight. Airspeed, airflow, temperature, humidity, density, and viscosity can be controlled due to conditions reenactments.

H2.11 Results

This graph shows the average of lift produced by each wing; each wing was tested in trails of 3 and the average was calculated for different angles of attack. Readings were recorded by a wind tunnel computer program.

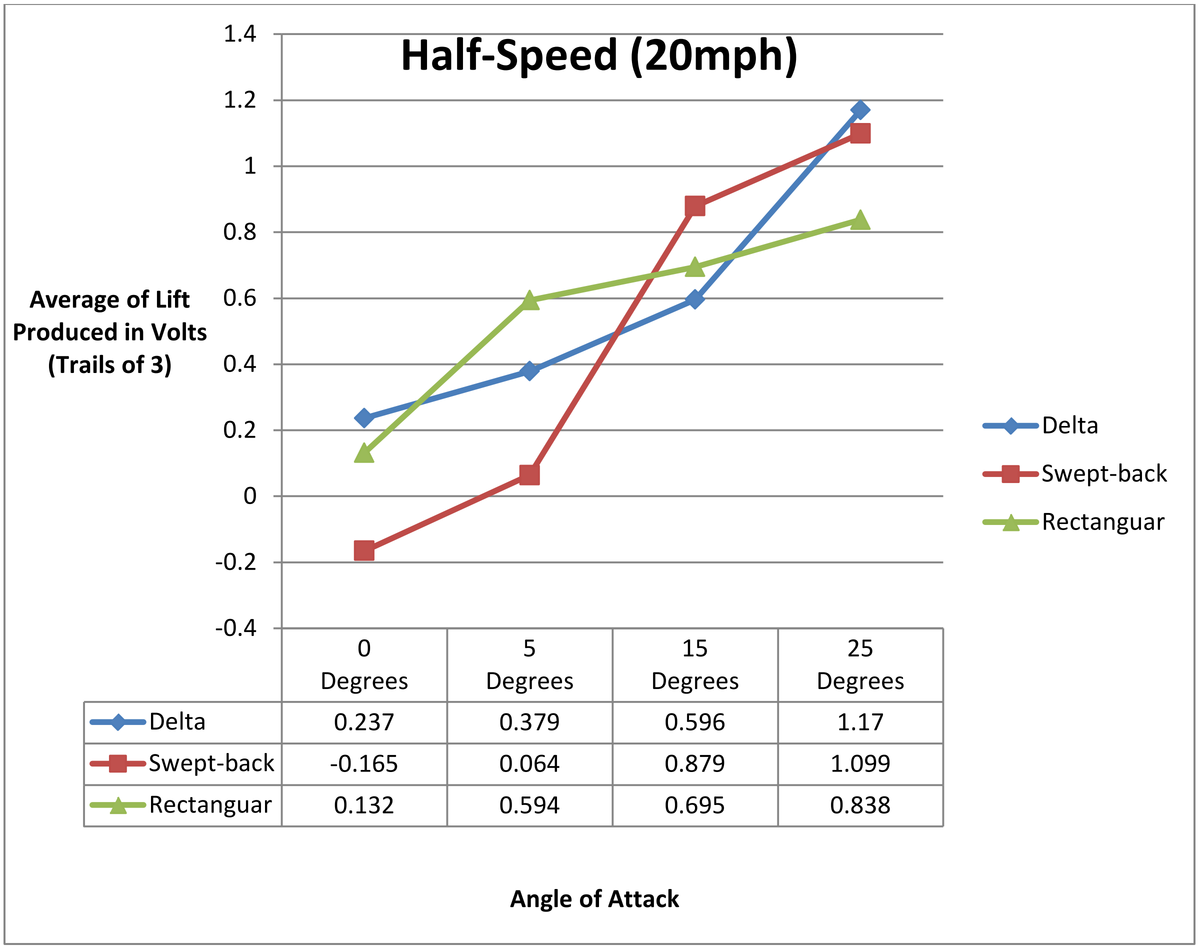
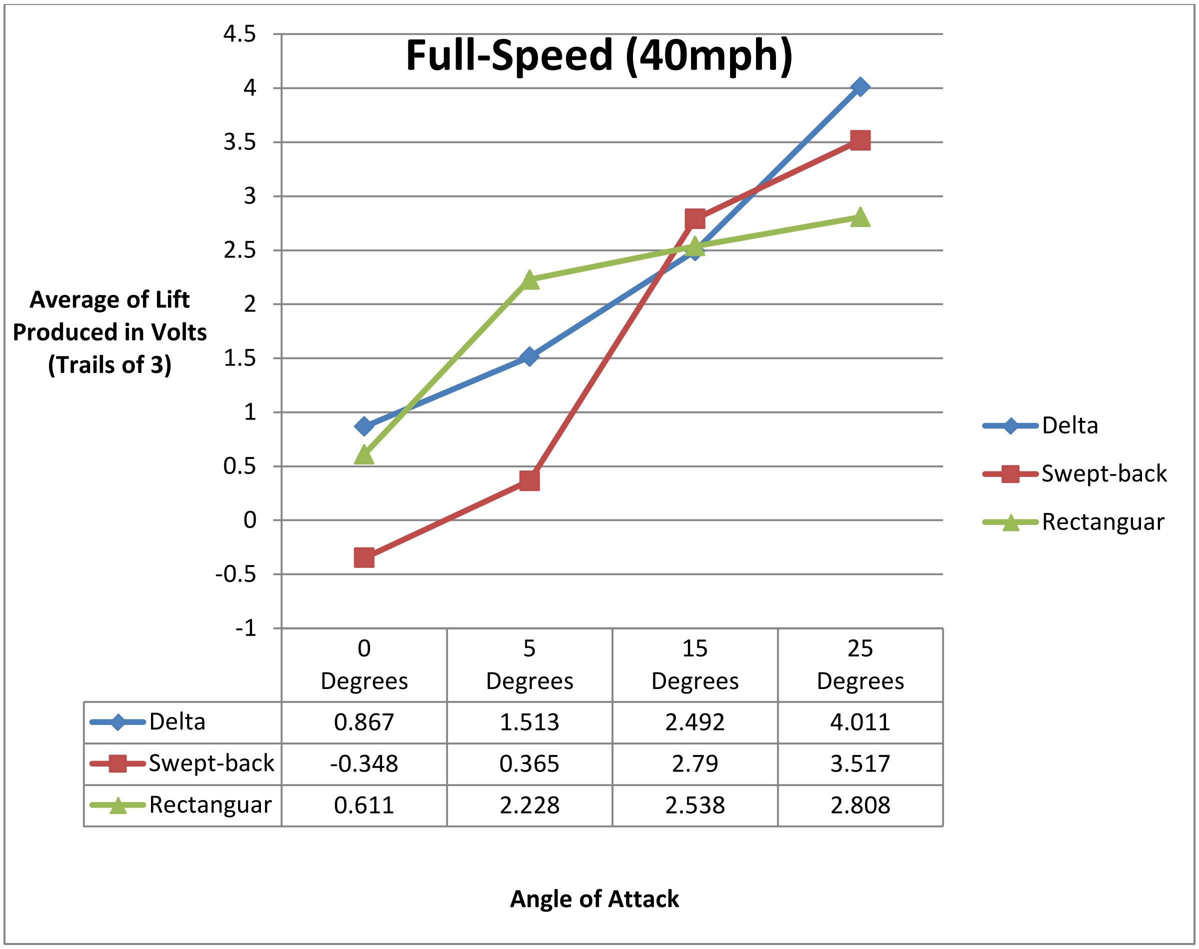


Figure H-21 Half-speed Lift Produced by Wings



	0 Degrees	5 Degrees	15 Degrees	25 Degrees
Delta	0.867	1.513	2.492	4.011
Swept-back	-0.348	0.365	2.79	3.517
Rectanguar	0.611	2.228	2.538	2.808

Figure H-22 Full-speed Lift Produced

H2.11.1 Lift Coefficient (Half-Speed)

Delta: CL = 2(0.379) / 14.7 x 20^2 x 6
L = 0.379 (5° angle of attack)
ρ = 14.7 (Ground level density)
V = 20mph (Half-speed)
A = $6in^2$ (Area of the wing)
CL = 0.00002449

Delta: CL = 2(0.596) / 14.7 x 20^2 x $6in^2$
L = 0.596 (15° angle of attack)
ρ = 14.7
V = 20mph
A = $6in^2$
CL = 0.00003379

Delta: CL = 2(1.17) / 14.7 x 20^2 x $6in^2$
L = 1.17 (25° angle of attack)
ρ = 14.7
V = $20mph^2$

$A = 6in^2$
CL = 0.0000056063

Swept-back: $CL = 2(0.064) / 14.7 \times 20mph^2 \times 6in^2$
L = 0.64 (5° angle of attack)
$\rho = 14.7$
$V = 20mph^2$
$A = 6in^2$
CL = 0.00363

Swept-back: $CL = 2(0.879) / 14.7 \times 20mph^2 \times 6in^2$
L = 0.879 (15°angle of attack)
$\rho = 14.7$
$V = 20mph^2$
$A = 6in^2$
CL = 0.00004983

Swept-back: $CL = 2(1.099) / 14.7 \times 20mph^2 \times 6in^2$
L = 1.099 (25° angle of attack)
$\rho = 14.7$
$V = 20mph^2$
$A = 6in^2$
CL = 0.00006230

Rectangular: $CL = 2(0.594) / 14.7 \times 20mph^2 \times 6in^2$
L = 0.594 (5° angle of attack)
$\rho = 14.7$
$V = 20mph^2$
$A = 6in^2$
CL = 0.00003367

Rectangular: $CL = 2(0.594) / 14.7 \times 20mph^2 \times 6in^2$
L = 0.695 (15° angle of attack)
$\rho = 14.7$
$V = 20mph^2$
$A = 6in^2$
CL = 0.0000394

Rectangular: $CL = 2(0.838) / 14.7 \times 20mph^2 \times 6in^2$
L = 0.838 (25° angle of attack)
$\rho = 14.7$
$V = 20mph^2$
$A = 6in^2$
CL = 0.0000475

Table H-13 Coefficient of lift (Half-speed)

Coefficient of Lift (Half-Speed)			
	Delta	Swept-back	Rectangular
5°	0.00002449	0.000005063	0.00003367
15°	0.00003379	0.00004983	0.0000394
25°	0.00006632	0.00006230	0.0000475

H2.11.2 Lift Coefficient (Full-speed)

Rectangular: CL = 2(2.228) / 14.7 x 40^2 x $6in^2$
L = 2.228 (5° angle of attack)
ρ = 14.7 (Ground-level density)
V = $40mph^2$ (Full-speed)
A = $6in^2$ (Area of wings)
CL = 00003.98

Rectangular: CL = 2(2.538) / 14.7 x 40^2 x $6in^2$
L = 2.238 (15° angle of attack)
ρ = 14.7
V = $40mph^2$
A = $6in^2$
CL = 0.0003595

Rectangular: CL = 2(2.808) / 14.7 x 40^2 x $6in^2$
L = 2.808 (25° angle of attack)
ρ = 14.7
V = $40mph^2$
A = $6in^2$
CL = 0.0000398

Delta: 2(1.513) / 14.7 x 40^2 x $6in^2$
L = 1.513 (5° angle of attack)
ρ = 14.7
V = $40mph^2$
A =$6in^2$
CL = 0.0002144

Delta: 2(2.492) / 14.7 x 40^2 x $6in^2$
L = 2.492 (15° angle of attack)
ρ = 14.7
V = $40mph^2$
A = $6in^2$
CL = 0.00003532

Delta: 2(4.011) / 14.7 x 40^2 x $6in^2$

L = 4.011 (25° angle of attack)
ρ = 14.7
V = 40^2
A = $6in^2$
CL = 0.00005685

Swept-back: $2(.365) / 14.7 \times 40^2 \times 6in^2$
L = .365 (5° angle of attack)
ρ = 14.7
V =$40mph^2$
A = $6in^2$
CL = 0.000005173

Swept-back: $2(2.79) / 14.7 \times 40^2 \times 6in^2$
L = 2.79 (15° angle of attack)
ρ = 14.7
V = $40mph^2$
A = $6in^2$
CL = 0.00003954

Swept-back: $2(3.517) / 14.7 \times 40^2 \times 6in^2$
L = 3.517 (25° angle of attack)
ρ = 14.7
V = $40mph^2$
A = $6in^2$
CL = 0.00004984

Table H-14. Coefficient of lift

Coefficient of Lift (Full-speed)			
	Delta	Swept-back	Rectangular
5°	0.0002144	0.000005173	00003.98
15°	0.00003532	0.00003954	0.0003595
25°	0.00005685	0.00004984	0.0000398

H2.11.3 Induced drag Coefficient (Half-speed)

Rectangular: $Cd_i = 00003.367^2$ / pi x 2.7 x 1
CL = 00003.367^2 (5° angle of attack)
pi = 3.14
AR = 2.7
e = 1
$Cd_i =$ 1.337

Rectangular: $Cd_i = 00003.94^2 / \pi \times 2.7 \times 1$
CL = 00003.94^2 (15° angle of attack)
pi
AR = 2.7
e = 1

Cd_i = 1.830

Rectangular: $Cd_i = 00004.75^2$ / pi x 2.7 x 1
CL = 4.75^2 (25° angle of attack)
pi
AR = 2.7
e = 1
Cd_i =2.66

Delta: $Cd_i = 00002.149^2$ / pi x 2.7 x 1
CL = 00002.149^2 (5° angle of attack)
pi
AR = 2.7
e = 1
Cd_i = 0.544

Delta: 00003.379^2 / pi x 2.7 x 1
CL = 00003.379^2 (15° angle of attack)
pi
AR = 2.7
e = 1
Cd_i = 1.346

Delta: 00006.632^2 / pi x 2.7 x 1
CL = 00006.632^2 (25° angle of attack)
pi
AR = 2.7
e = 1
Cd_i = 5.185

Swept-back: 000005.063^2 / pi x 4.6 x 1
CL = 00005.063^2 (5° angle of attack)
pi
AR = 4.6
e = 1
Cd_i = 1.774

Swept-back: 00004.983^2 / pi x 4.6 x 1
CL = 00004.983^2 (15° angle of attack)
pi
AR = 4.6
e = 1
Cd_i = 1.718

Swept-back: 00006.230^2 / pi x 4.6 x 1
CL = 00006.230^2 (25° angle of attack)

pi
AR = 4.6
e = 1
Cd_i = 2.686

Table H-15 Induced drag coefficient

	Induced Drag Coefficient (Half-Speed)		
	Delta	Swept-back	Rectangular
5°	0.544	1.774	1.337
15°	1.346	1.718	1.830
25°	5.185	2.686	2.66

H2.11.4 Induced Drag Coefficient (Full-Speed)

Rectangular: 0.00003158^2 / pi x 2.7 x 1
CL = 0.00003158^2 (5° angle of attack)
pi = 3.14
AR = 2.7
e = 1
Cd_{i} = 1.176

Rectangular: 0.00033595^2 / pi x 2.7 x 1
CL = 0.00033595^2 (15° angle of attack)
pi
AR = 2.7
e = 1
Cd_{i} = 1.524

Rectangular: 0.0000475^2 / pi x 2.7 x 1
CL = 0.0000475^2 (25° angle of attack)
pi
AR = 2.7
e = 1
Cd_i = 1.867

Swept-back: 0.000005173^2 / pi x 4.6 x 1
CL = 0.000005173^2 (5° angle of attack)
pi
AR = 4.6
e = 1
Cd_i = 1.852

Swept-back: 0.00003954^2 / pi x 4.6 x 1
CL = 0.00003954^2 (15° angle of attack)
pi
AR = 4.6

$e = 1$
$Cd_i = 1.082$

Swept-back: 0.00004894^2 / pi x 4.6 x 1
CL = 0.00004894^2 (25° angle of attack)
pi
AR = 4.6
$e = 1$
$Cd_i = 1.719$

Delta: 0.00002144^2 / pi x 2.7 x 1
CL = 0.00002144^2 (5° angle of attack)
pi
AR = 2.7
$e = 1$
$Cd_i = 0.542$

Delta: 0.00003532^2 / pi x 2.7 x 1
CL = 0.00003532^2 (15° angle of attack)
pi
AR = 2.7
$e = 1$
$Cd_i = 1.471$

Delta: 0.00005685^2 / pi x 2.7 x 1
CL = 0.000056852 (25° angle of attack)
pi
AR = 2.7
$e = 1$
$Cd_i = 3.810$

H2.11.5 Induced Drag Coefficient (Full-Speed)

Table H-16. Induced drag coefficient (Full-speed)

	Delta	Swept-back	Rectangular
5°	0.542	1.852	1.176
15°	1.471	1.082	1.524
25°	3.810	1.719	1.867

H2.12 Discussion

Before cutting out the wing shapes on the form board, each wing had to be the same area because more area will result more drag which would be a disadvantage, the area equaled $6in^2$. The wind tunnel that was used was the ScanTek 2000.

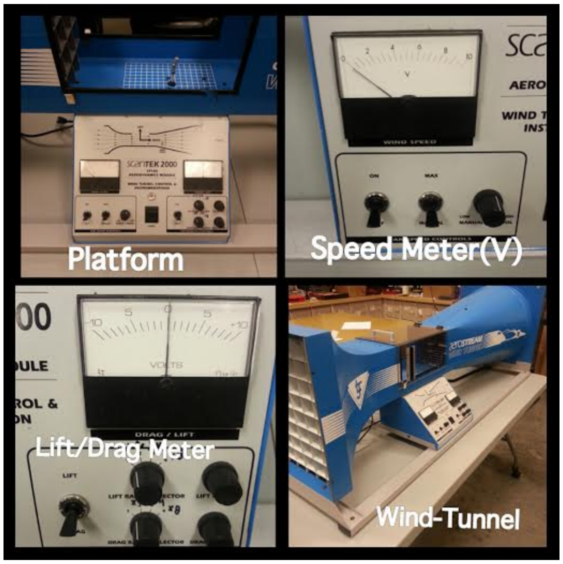


Figure H-23 Platform, Speed Meter, L/D Meter and ScanTek 2000 Wind Tunnel Used

The ScanTek 2000 had to be calibrated from bumps, pervious testing's, and zeroed out for lift. Weights were used on the testing platform to get a precise reading, meaning most legible readings for the wings that were tested. The weights used were 20kg, 50kg, and 75kg and placed on the wind-tunnel platform. For the induced drag equation, lift needed to be recorded at different angles of attack (5°, 15°, 25°) at 20mph and 40mph. After gathering readings recorded from lift, the coefficient of lift was calculated.

Figure H-24 Calibration Process Equipment

After the coefficient of lift was calculated (CL) it was placed into the induced drag equation, (Cd_{i})). The way each wing was calculated for induced drag was by taking different angles of attack in the readings of the lift coefficient at different angles of attack. After the half-speed induced drag coefficient was calculated, it was placed in the graphs provided in this report, same as the half-speed coefficient of lift, the lift coefficient at full-speed, as well as full-speed induced drag coefficient. For the amount of lift produced in the wing tunnel, the graphs show how each wing reacted with different angle of attacks and wind-speeds.

H2.13 Conclusion

In conclusion, the hypothesis was correct; the delta wing at 5° angle of attack at 40mph winds had the least amount of induced drag compared to the swept-back and rectangular designs. Aircrafts that has a lot of speed using delta wings will have the least amount of induced drag. Also with increased angle of attack, lift increases, and then lowers the speed which will create induced drag, that's why the delta wing at 5° angle of attack going 40mph had least amount of induced drag.

Aircrafts that uses wings that produce the most amount of lift will have the most induced drag due to lift, meaning rectangular shaped wings are used for cruising. Notice that the delta wing at 25° angle of attack had the most amount of lift, in result, had the most amount of induced drag. The delta wing had the most lift because the trailing edge across the fuselage produces a lot of lift due to its enclosed shape allowing greater air pressure from the bottom of the wing (Refer to *How Aircrafts Fly*). The swept-back wing at 5° angle of attack had the least amount of lift, but a bigger aspect ratio (4.6) compared to the delta wing 2.7 aspect ratio which compared to the swept-back didn't produced a lot of lift which in result, came out to have the least amount of induced drag.

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H3. Robotic Navigation Sensor Difference, Jasmin Sanford, Grade 12

H3.1 Abstract

The topic of this research inquiry project is robotic programming; the investigation will cover how different navigation styles will affect the performance of a robot on an obstacle course. The purpose of this investigation is to observe how a robot responds to an obstacle with either tactile navigation or infrared headlights better. The question of this investigation was the following. Which type of navigation is more efficient to use on a robot to follow a course? The robot will be programmed using PBASIC. The formed hypothesis for this investigation was based on the little knowledge of programming and sensors. If the Boe-Bot is built with the whiskers and uses tactile navigation instead of infrared detection then, when the Boe-Bot comes in contact with an obstacle, it will have a more reliable response to it and will reroute with less errors because, the whiskers allow a physical contact with barriers and gives a more appropriate solution away from the obstacle. Materials used in this project are a computer, Boe-Bot robot kit, PBasic software, self-designed obstacle course, and a logbook. The response of the robot to the detection based on the different navigation methods will be recorded based on the performance of the robot on the course. The hypothesis being in favor of the tactile navigation was proven correct because it is more dependable than the infrared which detects objects through their color and wavelengths.

H3.2 Introduction

The topic of this research inquiry project is robotic programming; the investigation will cover how different navigation styles will affect the performance of a robot on an obstacle course. As a participant in the high school’s Math and Science Club and member of the FIRST Robotics team since 2009, interest in this project was sparked by the fact that programming is an important factor in building a robot for the annual game from FIRST and not many team members are knowledgeable of language, skills required, or actual field present for robotic programming. The purpose of this particular investigation is to observe how a robot responds to an obstacle with either tactile navigation or infrared headlights better.

H3.3 Technical Background

The question of this investigation is as follows:

- Which type of navigation is more efficient to use on a robot to follow a course?
    - The robot will be programmed using PBASIC.

The formed hypothesis of this investigation is as follows:

- If the Boe-Bot is built with the whiskers and uses tactile navigation instead of infrared detection then, when the Boe-Bot comes in contact with an obstacle, it will have a more reliable response to it and will reroute with less errors

because, the whiskers allow a physical contact with barriers and gives a more appropriate solution away from the obstacle.

H3.4 Background Research

H3.4.1 What Language to Choose

There are many programming languages which can be used to program microcontrollers, the most common of which are:

- **Assembly**; it's just one step away from machine code and as such it is very tedious to use. Assembly should only be used when you need absolute instruction-level control of your code.
- **Basic;** one of the first widely used programming languages; it is still used by some microcontrollers (Basic Micro, BasicX, Parallax) for educational robots.
- **C/C++;** one of the most popular languages, C provides high-level functionality while keeping a good low-level control.
- **Java**; it is more modern than C and provides lots of safety features to the detriment of low-level control. Some manufacturers like Parallax make microcontrollers specifically for use with Java.
- **.NET/C#**; Microsoft's proprietary language used to develop applications in Visual Studio. Examples include Netduino, FEZ Rhino and others).
- **Processing** (Arduino); a variant of C++ that includes some simplifications in order to make the programming for easier.
- **Python**, one of the most popular scripting languages. It is very simple to learn and can be used to put programs together very fast and efficiently.

H3.4.2 What Is an Object?

An object is a software bundle of related state and behavior. Software objects are often used to model the real-world objects that you find in everyday life. This lesson explains how state and behavior are represented within an object, introduces the concept of data encapsulation, and explains the benefits of designing your software in this manner.

H3.4.3 Variables

You've already learned that objects store their state in fields. However, the Java programming language also uses the term "variable" as well. This section discusses this relationship, plus variable naming rules and conventions, basic data types (primitive types, character strings, and arrays), default values, and literals.

H3.4.4 Types of Variables

Javascript supports three types of simple variables. These are text, numbers, and Boolean (true or false). In this case this variable is a text variable because the value we have initialized it with is text (because it is enclosed within apostrophes). Had we wanted to define the variable as a number then we would have given it a numeric value (not enclosed in apostrophes) like this:

```
var mynum = 5;
```

We could also have defined the variable as boolean by assigning it an initial value of true or false. For example:

```
var smokes = false;
```

If you don't assign a value to the variable straight away then the type of variable that it is will be undefined until you give it a value.

You can leave a variable undefined when you don't want to assign it an initial value but a better alternative where you don't want to give the variable a value straight away is to specify that the variable doesn't have a value at all. We do this by initializing the variable with **null** like this:

```
var riches = null;
```

Javascript also allows you to define and use more complex data types that are defined using classes. We'll go into more detail about classes in a later tutorial but here's an example of a variable defined from a class so that you know what they look like:

```
var today = new Date;
```

H3.4.5 Naming Variables

So what should you call your variables? The best option (at least to start with) is to use meaningful names for all of your variables. If you call your variable **openingPrice** then you are far more likely to remember what the field is used for when you need to modify the script at a later date than if you call it **op**. The only restriction on what names you can use for your variables is that you can't use reserved words and all of the characters you use in the variable names must be alphanumeric. Reserved words are words that currently (or are expected in the future) to have a special meaning in the Javascript programming language. Examples of reserved words that you have already met include "var", "true", "false", "new", and "null". You'll find a complete list of reserved words elsewhere on this site.

Note that variable names cannot contain spaces. This means that when you use multiple words in a variable name that you must either separate the words with an underscore character (the only non alphabetic and non number character that nevertheless is considered to be alphanumeric) - for example: opening_balance - or you can do as I did in the previous paragraph and capitalize the first letter of the second and subsequent words. It doesn't matter which of these two options you choose but I suggest that you use that one consistently for your variable names rather than switching between them.

H3.4.6 Hardware and Software

Getting started with BASIC Stamp microcontroller modules is similar to getting started with a brand-new PC or laptop. The first things that most people have to do is take it out of the box, plug it in, install and test some software, and maybe even write some software of their own using a programming language. If this is your first time using a BASIC Stamp module, you will be doing all these same activities. If you are in a class, your hardware may already be all set up for you. If this is the case, your teacher may have other instructions. If not, this chapter will take you through all the steps of getting your new BASIC Stamp microcontroller up and running.

What is a Microcontroller

A small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications.

What is a Command
It is an instruction to a computer or device to perform a specific task. Commands come in different forms. Every program that interacts with people responds to a specific set of commands. The set of commands and the syntax for entering them is called the *user interface* and varies from one program to another.

What is a Function
In programming, a named section of a program that performs a specific task. In this sense, a function is a type of procedure or routine. Some programming languages make a distinction between a *function*, which returns a value, and a *procedure*, which performs some operation but does not return a value.

Navigation
The act, activity, or process of finding the way to get to a place when you are traveling in a ship, airplane, car, etc.: The act of moving in a boat or ship over an area of water
Computers: the act of going to different places on the Internet or on a particular Web site in order to find what you want.

Tactile sensor
Usually refers to a transducer that is sensitive to touch, force, or pressure. Tactile sensors are employed wherever interactions between a contact surface and the environment are to be measured and registered. Tactile sensors are useful in a wide variety of applications for robotics and computer hardware and even security systems. Tactile sensors have a great impact and influence on much of today's societal progression. They are used in several common items such as brakes, clutches, door seals, gasket, battery lamination, bolted joints and fuel cells. Many types of robotic machinery rely on a variety of tactile switches. Switches provide inputs that dictate other forms of programmed output.

H3.4.7 Infrared Detection
An infrared detector is a detector that reacts to infrared (IR) radiation. The response time and sensitivity of photonic detectors can be much higher, but usually these have to be cooled to cut thermal noise. The materials in these are semiconductors with narrow band gaps.
Many remote controls and PDA's use signals in the infrared frequency range to communicate, below is the visible light spectrum. Some robots use either sonar or radar infrared detection.

Table H-17. Colors and Approximate Wavelengths

Color	Wavelength	Color	Wavelength
Violet	400	Red	780
Blue	470	Near infrared	800-1000
Green	565	Infrared	1000-2000
Yellow	590	Far infrared	2000-10,000
Orange	630		

Infrared detection devices are sensors that detect radiation in the infrared portion of the electromagnetic spectrum (>1012 to 5 × 1014 Hz). Often, such devices form the information

they gather into visible-light images for the benefit of human users; alternatively, they may communicate directly with an automatic system, such as the guidance system of a missile.

H3.4.8 Principles of infrared detection

Infrared—"below-red"—light consists of electromagnetic radiation that is too low in frequency (i.e., too long in wavelength) to be perceived by the human eye, yet is still too high in frequency to be classed as microwave radio. Infrared (IR) light that is just beyond the human visual limit ($>1.0 \times 10^{14}$ to 4.0×10^{14} Hz) is termed near IR, while light farther from the visible spectrum is divided into middle IR, far IR, and extreme IR.

There are two basic designs for electronic IR imagers. The first is the scanner. In this design, light from a tiny portion of the scene to be imaged is focused by an optical and mechanical system on a small circuit element that is sensitive to photons in the desired IR frequency range. The intensity of the signal from the IR detector element is recorded, then the mechanico-optical system shifts its focus to a different fragment of the scene. The response of the IR detector element is again recorded, the view shifts again, and so forth, systematically covering the scene. Many scene-covering geometries have been employed by scanning imagers; the scanner may record horizontal or vertical lines (rasters), spiral outward from a central point, cover a series of radii, and so on.

The second basic type of IR imaging system is the "starer." Such a system is said to "stare" because its optics do not move like a scanner's, scanning the scene a little bit at a time; instead, they focus the image onto an extended focal plane. Located in this plane is a flat (planar) array of tiny sensors, each equivalent to the single IR sensor employed in a scanning system. By measuring the IR response of all the elements in the flat array simultaneously (or rapidly), the system can record an entire image at once. Image resolution in a staring scanner is limited by the number of elements in the array, whereas in a scanning system it is limited by the size of the scanning dot.

H3.5 Materials

1. Computer
2. BoeBot Robot kit
3. Parallax PBASIC software
4. Self-designed obstacle course
    a. Duct tape
    b. Medium spaced field
    c. Wooden barriers (for walls)
5. Logbook

H3.6 Methods

To ensure that accurate data is collected for each program the robot will go through three individual trials for each program.
The following are the methods for this investigation:

1. Build the Boe-Bot design for the tactile navigation
2. Build model obstacle course for robot to run on

3. Write the program for the tactile navigation
4. Run the robot with the RevisedRoamingWithWhiskers.bs2 program
5. Record results
    a. Performance through course (accurate turns/responses)
    b. Time taken to complete course
6. Reset course if needed
7. Run robot on course for two more trials
8. Reset obstacle course again
9. Build Boe-Bot for the infrared detection navigation
10. Write the program for the infrared dectection
11. Run the robot with the RevisedRoamingWithIr.bs2 program
12. Record results
    a. Performance through course (accurate turns/responses)
    b. Time taken to complete course
13. Reset course I needed
14. Run robot for two more trials
15. Compare and record all data

H3.7 Data and Results

Below are the results to how many turns the robot made accurately in response to how the course was set up.

Table H-18. Navigation Responses

Trial	Tactile Navigation Response	Infrared Detection Response
1	80%	60%
2	60%	40%
3	80%	80%

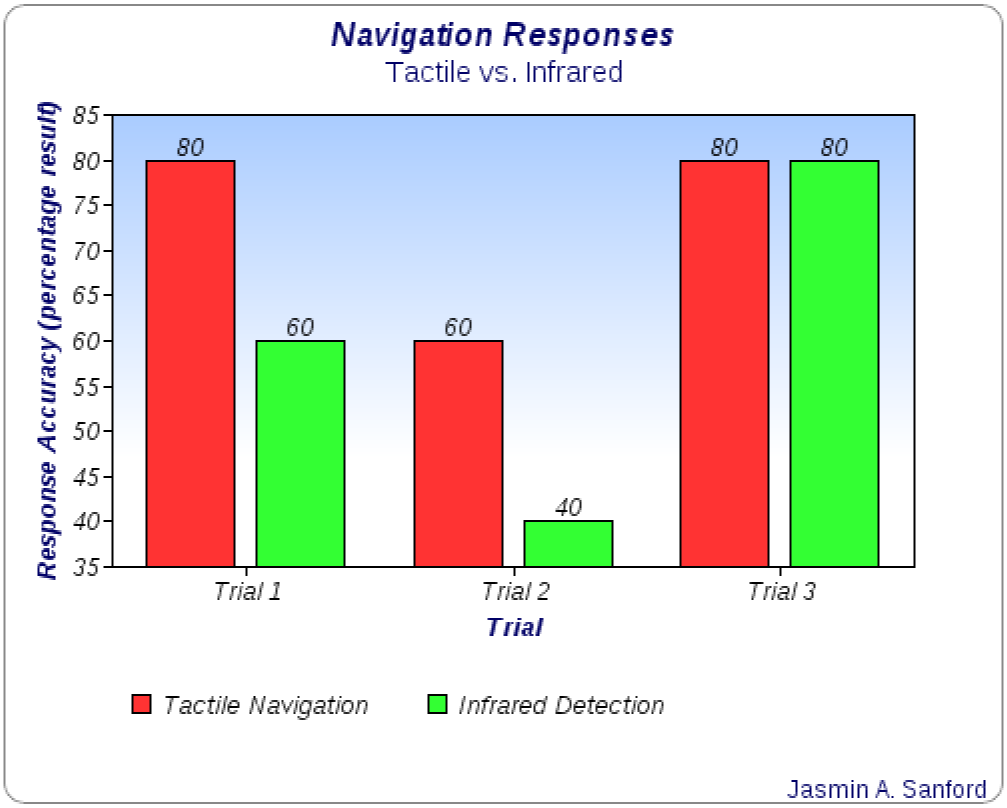

Figure H-25 Navigation Responses: Tactile vs. Infrared

Below is the response time that it took for the robot to complete the course after each trial.

Table H-19. Navigation Time

Trial	Tactile Navigation Time	Infrared Detection Time
1	1min 25sec	1min 26sec
2	1min 24sec	1min 26sec
3	1min 26sec	1min 27sec

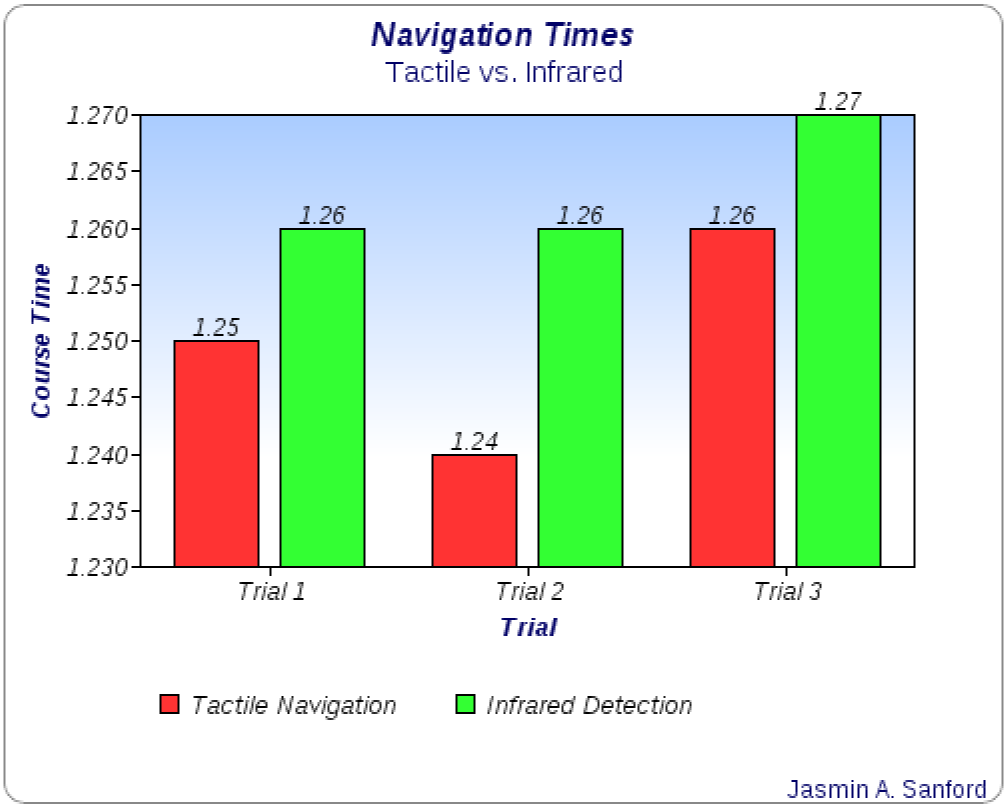

Figure H-6. Navigation Times: Tactile vs. Infrared

H3.8 Discussion

The tactile switches on the robot are called whiskers. Although the robot did not complete the course successfully hitting all five barriers in any trial enough information was gathered to come to a consensus of a conclusion. It was proven through the results of times for the robot to complete the course, or even come close to it in each trial that tactile navigation- which relies solely on touch to react was the superior choice. The infrared detection used the properties of the objects on the course to react to each barrier. The time and response results could be close but have no correlation because there was only one Boe-Bot model robot used to experiment. Therefore, it is a possibility that the servos could have begun to wear due to the repeated testing of both sensor configurations.

Further implications of this project would include testing with a much longer and complex course. It would be very beneficial to realign and test the servos, recheck all wiring schematics, and look through the programs to ensure the proper procedures are being done before retesting on the course. This would affect society by using technology to further promote robots and their extended use to humans. The greatest impact this experiment could have on the real world would be for the robot to be improved and made to run various errands or complete tasks such as, picking up medicine for the elderly, assisting with carrying heavy things through places and helping entertain children.

H3.9 Conclusion

The hypothesis being in favor of the tactile navigation was proven correct because it is more dependable than the infrared which detects objects through their color and wavelengths. The tactile navigation method had a higher average response rate of 73% and the infrared detection had an average response rate of 60%. The tactile navigation also took a lower average time of 1 minute 25 seconds, and the infrared detection method took an average time of 1 minute 26 seconds to come close to completing the course.

H3.10 Works Cited

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H4. Heat Vs Luminance: CFL VS LED, Kadijah Taylor, Grade 12

Table of Contents

H4.1 Abstract

Compact fluorescent light (CFL) and Light-emitting diode (LED) are energy- saving light bulbs. The problem was does a 12 watt LED light bulb with 820 lumens produce less heat than a 13 watt CFL light bulb with 825 lumens in a 30 minute time frame with a 120 volt power supply in a box with a total surface area of 951.7 inches? This problem helps determines if energy-saving light bulbs are safe for the household.

The hypothesis was If a 12 watt LED light bulb with 820 lumens and 13 watt CFL bulb with 825 lumens are put into a lamp mounted in the lid of a box with the height of 9.875 inches and dimensions of 15.75 x 12.5 x 9.875 inches and a 951.7 inch surface area, then the rate of change for temperature inside the box will be slower for the LED bulb within a 30 minute time frame with a 120 volt power supply because there is no mercury gas in a LED light bulb to heat and there is only straight current flow that flows through the LED light bulb.

A controlled environment was created. The separate trials were run in the following order: Illumination, Temperature, Luminance vs. temperature.

There was no direct correlation between temperature and luminance for the bulbs. The amount of illumination never stabilized. The LED had a lower percentage of change for temperature being 7.8%. The LED's lower percentage of change for temperature shows it is safer than the CFL.

H4.2 Introduction

H4.2.1 Statement of Research Question:

- Does a 12 watt LED light bulb with 820 lumens produce less heat than a 13 watt CFL light bulb with 825 lumens in a 30 minute time frame with a 120 volt power supply in a box with a total surface area of 951.7 inches?

H4.2.2 Hypothesis:

If a 12 watt LED light bulb with 820 lumens and 13 watt CFL bulb with 825 lumens are put into a lamp mounted in the lid of a box with the height of 9.875 inches and dimensions of 15.75 x 12.5 x 9.875 inches and a 951.7 inch surface area, then the rate of change for temperature inside the box will be slower for the LED bulb within a 30 minute time frame with a 120 volt power supply because there is no mercury gas in a LED light bulb to heat and there is only straight current flow that flows through the LED light bulb.

H4.2.3 Rationale for Hypothesis Development:

The reason for the hypothesis is because CFL and LED are the newest light bulbs in the energy saving development, but I wondered how can they both be energy saving when one, the CFL light bulb, conducts light via a reaction with mercury gas and the other, the LED light, produces light through a semiconductor. I don't believe they are completely the same but I want to understand their differences.

H4.2.4 Background Research:

Luminance is the rate that light falls on a surface measured in lux (lx). Occasionally the lambert unit is used to measure luminance. Flux means continuous change. Luminous flux is the rate of light emission measured in lumens (lm). Luminous intensity is the amount of light that falls on a defined surface measured in candela (cd).

Radiometry is the science of measuring light in any portion of then electromagnetic spectrum. The term is usually limited to the measurement of infrared, visible, and ultraviolet light using optical instruments. Radiance is the intensity of light and is measured in watts per square meter. (Radiometry & Photometry: An overview of the science of measuring light)

Photometry is the science of measuring visible light in units that are weighted according to the sensitivity of the human eye. It is a quantitative science based on a statistical model of human visual response to light under carefully controlled conditions. The photometric equivalent of

radiance is called luminance and is measured in lumens per square meter (Lux). (Radiometry & Photometry: An overview of the science of measuring light)

The fundamental unit of photometry is the candela, which is a measure of light intensity, or candle power. The visible radiation (light) emitted by a light source is referred to as luminous flux and is expressed in units called lumens. The total luminous flux of a light source with a uniform intensity of one candela in all directions is about 12.6 lumens. (A typical 100 – watt light bulb emits about 1700 lumens.) The illumination of a surface is a measure of light it receives per unit of surface area. The illumination from a point source of light varies according to the inverse square law, which states that illumination varies as the inverse of the square of the distance to the light source. A lux is the illumination produced on a surface that is everywhere one meter from a point source of light with an intensity of one candela. One lux is the illumination produced by one lumen of luminous flux on a surface of one square meter. A footcandle is the illumination of one lumen on a surface of one square foot. One lux is equal to about 0.09 footcandles. (Photometry, 2009)

Comparison photometers measure the strength of light by comparing it with a standard light (one of known intensity). Bench photometers, of which there are several types, the light to be measured and a standard light are mounted on opposite ends of a bench. Between them is a device that allows the observer to compare the amount of light given off by each source. This device is moved until it is at a point where the two sources produce the same amount of illumination. The candlepower of the unknown source is then calculated. (Photometry, 2009)

Photoelectric photometers contain light-sensitive devices that convert light into electricity or undergo changes in electrical resistance when exposed to light. These devices are called photoelectric cells, or photocells. Two important types of photoelectric cells are photovoltaic cells and photoconductive, or photo resistor, cells. The photovoltaic cell generates an electric current when light falls on it. The photoconductive cell undergoes changes in electrical resistance when exposed to light and regulates the flow of current that is supplied by a battery or other electric power source. In both types of cells the strength of the current varies with the amount of illumination. Intensity of light is determined by measuring the current with a galvanometer, micro ammeter, or other electric meter. Photoelectric photometers are more accurate and easier to use. (Photometry, 2009)

Lambert is the unit of luminance (brightness) in the centimetre-gram-second system of physical measurement. It is defined as the brightness of a perfectly diffusing surface that radiates or reflects one lumen per square centimetre. The unit was named for the 18th-century German physicist Johann Heinrich Lambert. (Encyclopedia Britannica)

Compact fluorescent light (CFL) light bulbs are low-wattage energy efficient fluorescence light bulb designed for use in standard light equipment such as table lamps. (Compact Fluorescent Light)

Incandescent light bulb also known as incandescent lamp is an electric lamp in which a filament is heated to a certain degree (7,500 degrees Fahrenheit) by an electric current. (Incandescent Lamp)

LED stands for light emitting diode and is a light bulb that emits light when an electrical current is passed through the device. (LED) An LED is what’s called solid-state lighting technology, also known as SSL. It emits light from a piece of solid matter. The piece of matter is called a semiconductor and a semiconductor produces light when electrons move around within its semiconductor structure. A semiconductor is made of a positively charges and a negatively charged component. The positive layer has holes – openings for electrons; the negative layer has

free electrons floating around in it. When an electric charge strikes the semiconductor, it activates the flow of electrons from the negative layer to the positive layer. The excited electrons emit light as they flow into the positively charged layer. (Layton, 2009)

Halogen light bulb also known as halogen lamp is a gas filled, high intensity incandescent lamp containing a small amount of a halogen gas, such as iodine. (Dictionary, 2010)

Heat is a form of energy. The SI system units are Joules. The common units are Calories and BTUs. A calorie is defined as the amount of energy required to increase the temperature of one gram of water by one degree Celsius. This is equivalent to 4.184 Joules. The BTU, which is the British Thermal Unit, is the amount of energy required to increase the temperature of one pound of water by one degree Fahrenheit. This is equivalent to 1055 Joules. Furnaces and air conditioners are expressed in BTUs. (Heat & Temperature)Temperature is the detected change in heat. When energy is added to the atoms of an object they begin to move faster and create heat. When energy is removed from the atoms of an object they start to move slower and cool off. (Heat & Temperature) Heat change is the heat energy put into an object by warming it from temperature one (T1) to temperature two (T2). The increase in heat (Q) is proportional to the temperature change (T2 – T1) and proportional to the mass (m) of the object being warmed. The proportionality constant (c), called specific heat, depends on the material the object is made of. The equation for heat change is: $Q = cm(T2 - T1)$. (Heat & Temperature) the heating rate is the rate in the change as time (t) passes. Temperature is proportional to heat in a sample of material temperature vs. time graph are indications of energy change. The equation for heating rate is $r = Q/t$. (Heat & Temperature)

Table H-20. The Equivalent Wattage between LED, CFL, and Incandescent

Light Output	LEDs	CFLs	Incandescent
Lumens	Watts	Watts	Watts
450	**4 - 5**	**8 - 12**	**40**
300 - 900	**6 - 8**	**13 - 18**	**60**
1100 - 1300	**9 - 13**	**18 - 22**	**75 - 100**
1600 - 1800	**16 - 20**	**23 - 30**	**100**
2600 - 2800	**25 - 28**	**30 - 55**	**150**

The highlighted section is the range that is desired to be tested.

Ohm's Law is a made from 3 mathematical equations that show the relationship that shows the relationship between electric voltage, current, and resistance. Voltage is the power supplied, current is the amount of power flow, and resistance is the limit on the power allowed to flow. Ohm's law was named after Bavarian Mathematician and physicist Georg Ohm (Basic Ohm's Law). Ohm's law states: The potential difference (voltage) across an ideal conductor is proportional to the current through it. The constant of proportionality is called resistance. Ohm's Law is given by: $V = I * R$, where V is the potential difference between two points which include a resistance (R). I is the current flowing through the resistance. For biological work, it is often preferable to use the conductance, $g = 1/V$; in this form ohm's law is $I = gV$. Material that obeys

ohm’s law is called “ohmic” or “linear” because the potential difference across it varies linearly with the current (Ohm's Law). Ohm’s Law wheel shows all the formulas for Power, Voltage, Current, and Resistance. Ohm’s Law wheel is shown below:

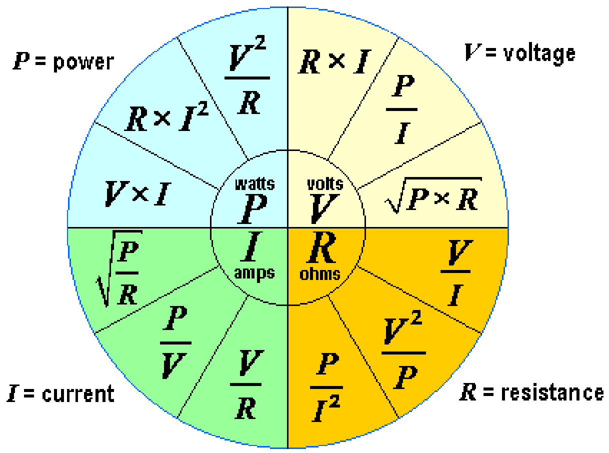

Figure H-27 Ohm’s Law Wheel

Alternating current, also known as AC, means that the direction of current flowing in a circuit is constantly being reversed back and forth. This is done with any type of AC current/voltage source. The electrical current inside a house is AC. This comes from the power plants that are operated by the electric company. The direction of the current is switching back and forth 60 times per second (Alternating Currect). Direct current, also known as DC, means it only moves in one direction. Batteries, Solar cells, fuels cells, and even some types of generators can produce DC current (Direct Current).

H4.3 Materials and Procedures

H4.3.1 Materials:

Portable hand lamp - 120 volt power
Light bulbs: 12 watt LED and 13 watt CFL
Calculator
Box with lid - Dimensions: Length – 15.75 “;Width – 12.5”; Height – 9.875”
Utility Knife
Temperature Probe
Lab quest
Light sensor
Logger Pro software

H4.3.2 Procedures:

1. Set up a controlled environment for testing
    a. Obtain a box with lid.
    b. Cut a hole in box lid for light insert.
    c. Cut holes on side of box for temperature probe and light sensor inserts.
2. Begin testing
    a. Place lamp into mount on box.

b. Screw the 13 watt CFL bulb into lamp.
c. Place light sensor into box.
    i. Connect light sensor to LabQuest
d. Turn on lamp and record data every 30 seconds for 30 minutes.
e. Turn off lamp and let light bulb cool.
f. Repeat steps b – e for the 7.5 watt LED light bulb.
g. Screw the 13 watt CFL bulb into lamp.
h. Place temperature probe into box.
    i. Connect temperature probe to LabQuest
i. Turn on lamp and record data every 30 seconds for 30 minutes.
j. Turn lamp off and let light bulb cool
k. Repeat steps g - j for the 7.5 watt LED light bulb.
l. Screw the 13 watt CFL bulb into lamp.
m. Place temperature probe and light sensor into box.
    i. Connect temperature probe and light sensor to LabQuest
n. Turn on lamp and record data every 30 seconds for 30 minutes.
o. Turn lamp off and let light bulb cool
p. Repeat steps l - o for the 7.5 watt LED light bulb.

H4.3.3 Identification of Variables:

Independent Variable:
- Light bulbs
- Time

Dependent Variables
- Heat

Controlled Variable:
- Power: watts
- Area: size of box

H4.3.4 Data Analysis Techniques

- Analysis Question
    - Which light bulb (CFL or LED) produce a faster increase in temperature?

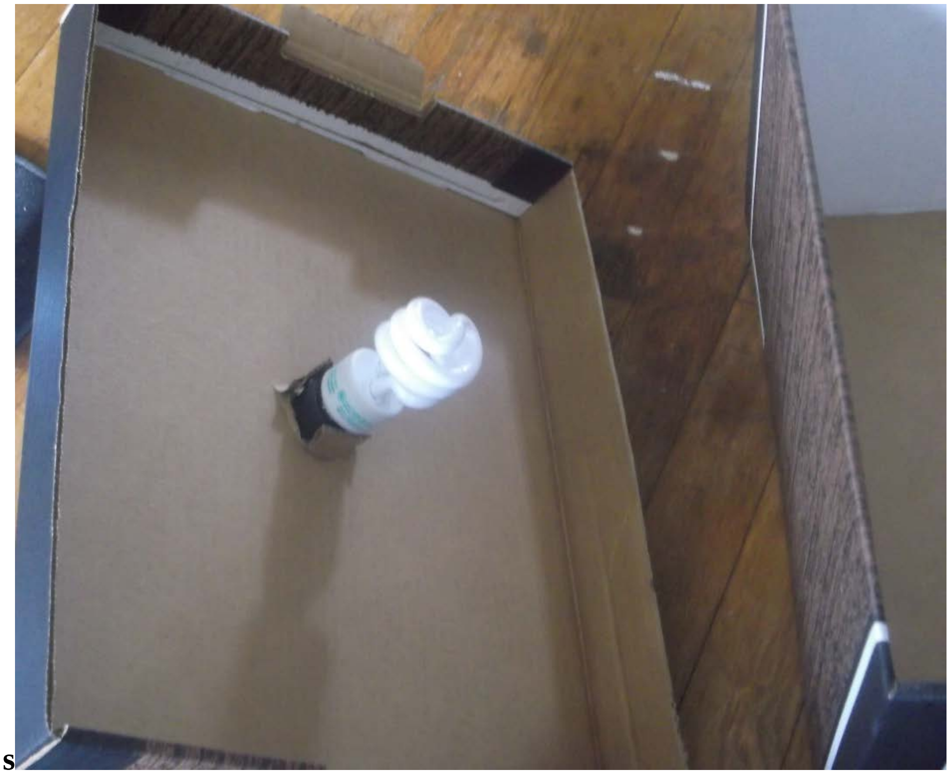

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Figure H-28 CFL Ready for testing

Figure H-29 LED Light bulb ready for testing

Figure H-30 Box ready for testing

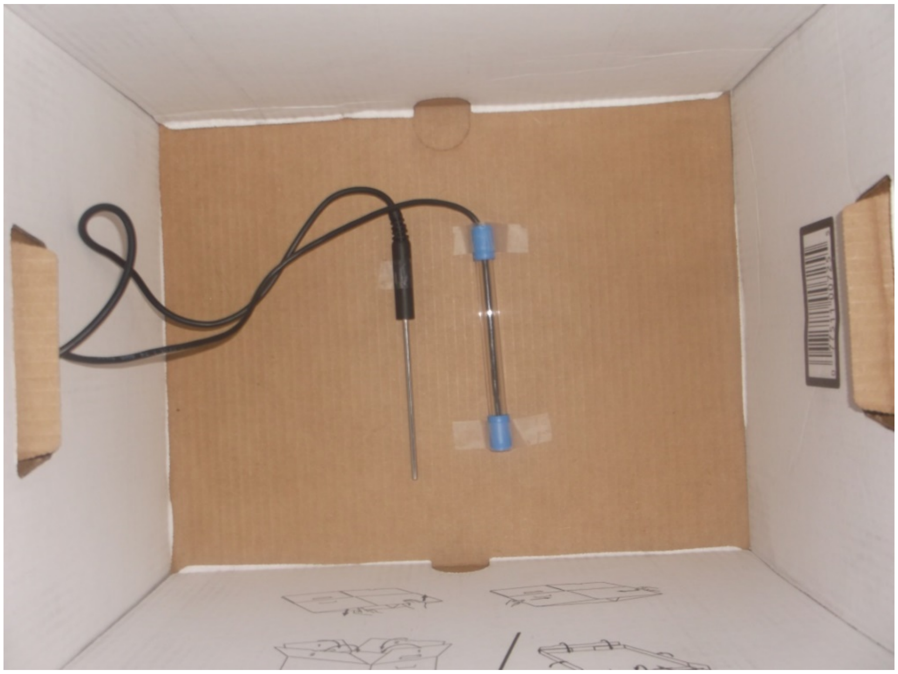

Figure H-31 Temperature Probe and Light Sensor in Place for Testing

Calculated the Current and Resistance for each light bulb to see the difference in the power usage.

- LED
    - Current

- $P = V \times I$
- $12\ w = 120\ v \times I$
- $12\ w / 120\ v = I$
- $I = 0.1$ amps
  - Resistance
    - $R = V^2/P$
    - $R = (120\ v)^2 / 12\ w$
    - $R = 14400\ v^2/12\ w$
    - $R = 1200$ ohms
- CFL
  - Current
    - $P = V \times I$
    - $13\ w = 120\ v \times I$
    - $13\ w / 120\ v = I$
    - $I = 0.1083$ amps
  - Resistance
    - $R = V^2/P$
    - $R = (120\ v)^2 / 13\ w$
    - $R = 14400\ v^2/13\ w$
    - $R = 1107.6923$ ohms

Then calculated the Illuminance and Luminous Intensity

- LED
  - Illuminance
    - $E = F/A$
    - $E = 820$ lm / 951.6875 inches
    - $E = 0.861627372$ lx
  - Luminous Intensity
    - $I = F/(4\pi)$
    - $I = 820\ lm/(4\pi)$
    - $I = 65.25352667$
- CFL
  - Illuminance
    - $E = F/A$
    - $E = 825$ lm / 951.6875 inches
    - $E = 0.866881198$ lx
  - Luminous Intensity
    - $I = F/(4\pi)$
    - $I = 825\ lm/(4\pi)$
    - $I = 65.65141403$

First set of trials were the Illumination Vs. Time trials for the CFL light bulb. Three trials were performed.

Table H-21: CFL Illumination Versus Time Trial 1

Time (Mins)	Illumination (lux)
0	0
0.5	900.6564331
1	761.1108398
1.5	750.9127808
2	937.5759888
2.5	931.3796997
3	947.7740479
3.5	919.1162109
4	754.9145508
4.5	744.7164917
5	847.3425293
5.5	761.1108398
6	859.6060181
6.5	863.7368774
7	867.7386475
7.5	814.4247437
8	703.6660767
8.5	826.8173218
9	674.8791504
9.5	668.8119507
10	746.7819214
10.5	717.9949951
11	756.9799805
11.5	668.8119507
12	765.2416992
12.5	662.6156616
13	789.8977661
13.5	674.8791504
14	717.9949951
14.5	818.555603
15	834.9499512
15.5	820.6210327
16	839.0808105
16.5	818.555603
17	713.8641357
17.5	722.1258545
18	876.0003662
18.5	871.8695068
19	869.8040771

Time (Mins)	Illumination (lux)
19.5	867.7386475
20	871.8695068
20.5	800.0958252
21	871.8695068
21.5	847.3425293
22	771.3088989
22.5	845.2770996
23	851.3442993
23.5	804.2266846
24	849.2788696
24.5	763.1762695
25	876.0003662
25.5	800.0958252
26	876.0003662
26.5	812.359314
27	822.6864624
27.5	806.2921143
28	843.2116699
28.5	754.9145508
29	853.409729
29.5	738.5202026
30	830.8190918

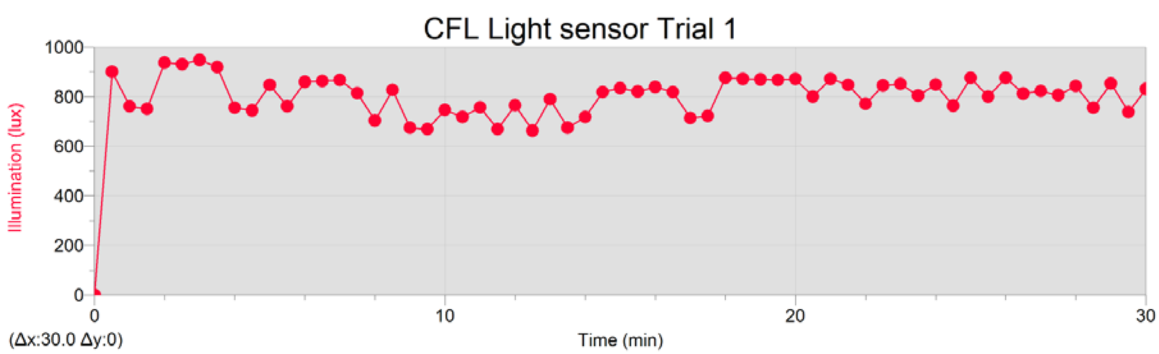

Figure H-32 Graph 1

Table H-22: CFL Illumination Versus Time Trial 2

Time (Mins)	Illumination (lux)
0	0
0.5	851.3442993
1	767.3071289
1.5	867.7386475
2	769.3725586

Time (Mins)	Illumination (lux)
2.5	871.8695068
3	734.3893433
3.5	880.1312256
4	748.8473511
4.5	763.1762695
5	777.505188
5.5	884.262085
6	865.8023071
6.5	834.9499512
7	855.4751587
7.5	886.3275146
8	845.2770996
8.5	720.0604248
9	855.4751587
9.5	765.2416992
10	793.8995361
10.5	777.505188
11	857.5405884
11.5	878.0657959
12	828.7536621
12.5	761.1108398
13	871.8695068
13.5	748.8473511
14	804.2266846
14.5	746.7819214
15	839.0808105
15.5	761.1108398
16	734.3893433
16.5	752.8491211
17	736.4547729
17.5	855.4751587
18	859.6060181
18.5	810.2938843
19	865.8023071
19.5	857.5405884
20	859.6060181
20.5	769.3725586
21	884.262085
21.5	880.1312256
22	812.359314
22.5	787.8323364

Time (Mins)	Illumination (lux)
23	886.3275146
23.5	876.0003662
24	767.3071289
24.5	756.9799805
25	884.262085
25.5	771.3088989
26	828.7536621
26.5	734.3893433
27	759.0454102
27.5	765.2416992
28	707.796936
28.5	878.0657959
29	865.8023071
29.5	839.0808105
30	853.409729

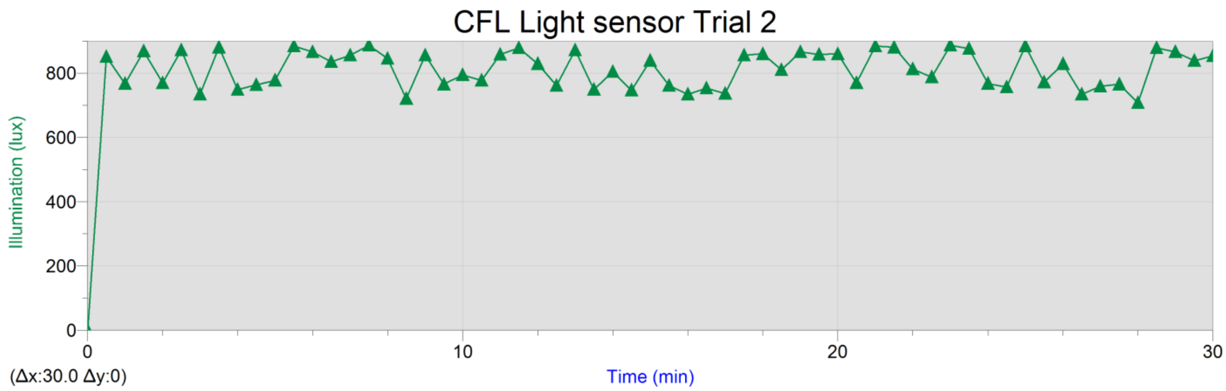

Figure H-33 Graph 2

Table H-23: CFL Illumination Versus Time Trial 3

Time (Mins)	Illumination (lux)
0	0
0.5	863.7368774
1	851.3442993
1.5	812.359314
2	824.7518921
2.5	795.9649658
3	863.7368774
3.5	763.1762695
4	771.3088989
4.5	867.7386475
5	845.2770996

Time (Mins)	Illumination (lux)
5.5	713.8641357
6	761.1108398
6.5	843.2116699
7	752.8491211
7.5	756.9799805
8	787.8323364
8.5	722.1258545
9	705.7315063
9.5	789.8977661
10	720.0604248
10.5	876.0003662
11	810.2938843
11.5	853.409729
12	873.9349365
12.5	812.359314
13	773.3743286
13.5	783.7014771
14	814.4247437
14.5	859.6060181
15	779.5706177
15.5	703.6660767
16	861.6714478
16.5	717.9949951
17	834.9499512
17.5	832.8845215
18	756.9799805
18.5	863.7368774
19	822.6864624
19.5	861.6714478
20	849.2788696
20.5	779.5706177
21	736.4547729
21.5	798.0303955
22	828.7536621
22.5	847.3425293
23	847.3425293
23.5	771.3088989
24	871.8695068
24.5	798.0303955
25	865.8023071
25.5	826.8173218

Time (Mins)	Illumination (lux)
26	867.7386475
26.5	759.0454102
27	763.1762695
27.5	863.7368774
28	703.6660767
28.5	724.1912842
29	841.1462402
29.5	765.2416992
30	849.2788696

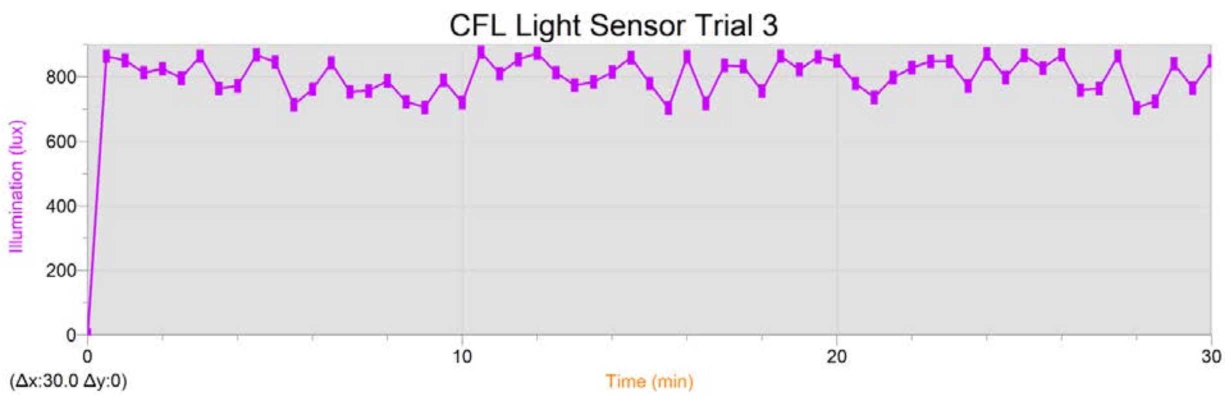

Figure H-34 Graph 3

LED Illumination Trials

Table H-24: LED Illumination Versus Time Trial 1

Time (Mins)	Illumination (lux)
0	0
0.5	1070.925293
1	1122.173767
1.5	676.9445801
2	1107.844849
2.5	1023.678589
3	1099.58313
3.5	1021.613159
4	1058.661804
4.5	861.6714478
5	765.2416992
5.5	804.2266846
6	847.3425293
6.5	705.7315063
7	793.8995361
7.5	1081.123352

Time (Mins)	Illumination (lux)
8	917.0507813
8.5	615.4980469
9	1064.729004
9.5	779.5706177
10	1050.400085
10.5	670.8773804
11	1068.859863
11.5	1044.203796
12	627.7615356
12.5	873.9349365
13	851.3442993
13.5	619.4998169
14	1031.940308
14.5	1052.465515
15	1031.940308
15.5	1056.596375
16	1040.202026
16.5	933.4451294
17	978.6264038
17.5	816.4901733
18	695.4043579
18.5	789.8977661
19	888.263855
19.5	832.8845215
20	697.4697876
20.5	648.2867432
21	726.2567139
21.5	1036.071167
22	605.1708984
22.5	1029.874878
23	791.8341064
23.5	1029.874878
24	642.0904541
24.5	668.8119507
25	658.4848022
25.5	697.4697876
26	919.1162109
26.5	992.9553223
27	814.4247437
27.5	1001.217041
28	603.1054688

Time (Mins)	Illumination (lux)
28.5	598.9746094
29	1013.48053
29.5	654.4830322
30	1013.48053

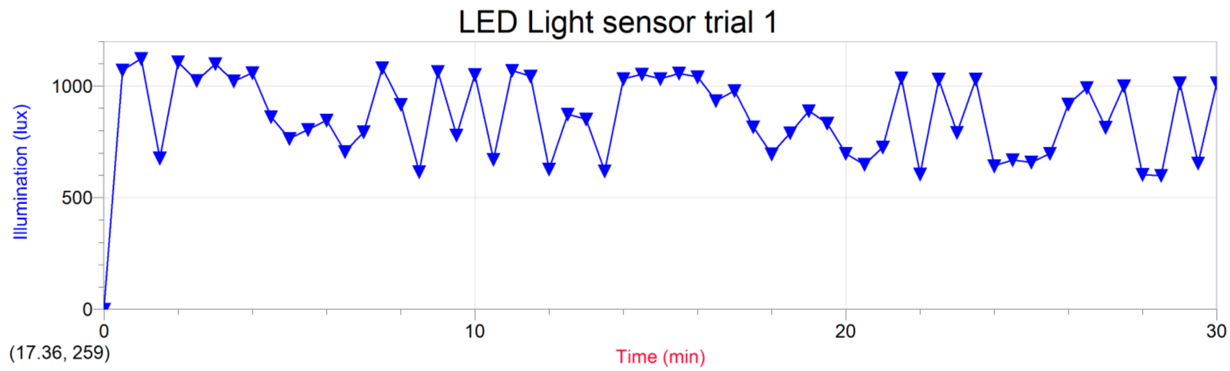

Figure H-35 Graph 4

Table H-25: LED Illumination Versus Time Trial 2

Time (Mins)	Illumination (lux)
0	0
0.5	958.1011963
1	629.8269653
1.5	1023.678589
2	966.2338257
2.5	931.3796997
3	927.2488403
3.5	832.8845215
4	1019.676819
4.5	863.7368774
5	937.5759888
5.5	947.7740479
6	849.2788696
6.5	869.8040771
7	980.6918335
7.5	964.168396
8	724.1912842
8.5	752.8491211
9	752.8491211
9.5	871.8695068
10	988.8244629
10.5	597.038269

Time (Mins)	Illumination (lux)
11	597.038269
11.5	748.8473511
12	931.3796997
12.5	601.0400391
13	754.9145508
13.5	943.7722778
14	970.3646851
14.5	894.460144
15	740.5856323
15.5	992.9553223
16	629.8269653
16.5	597.038269
17	845.2770996
17.5	798.0303955
18	826.8173218
18.5	976.5609741
19	720.0604248
19.5	601.0400391
20	771.3088989
20.5	1005.218811
21	1001.217041
21.5	681.0754395
22	931.3796997
22.5	648.2867432
23	939.6414185
23.5	976.5609741
24	752.8491211
24.5	662.6156616
25	843.2116699
25.5	943.7722778
26	1009.34967
26.5	1001.217041
27	695.4043579
27.5	697.4697876
28	674.8791504
28.5	597.038269
29	968.2992554
29.5	888.263855
30	919.1162109

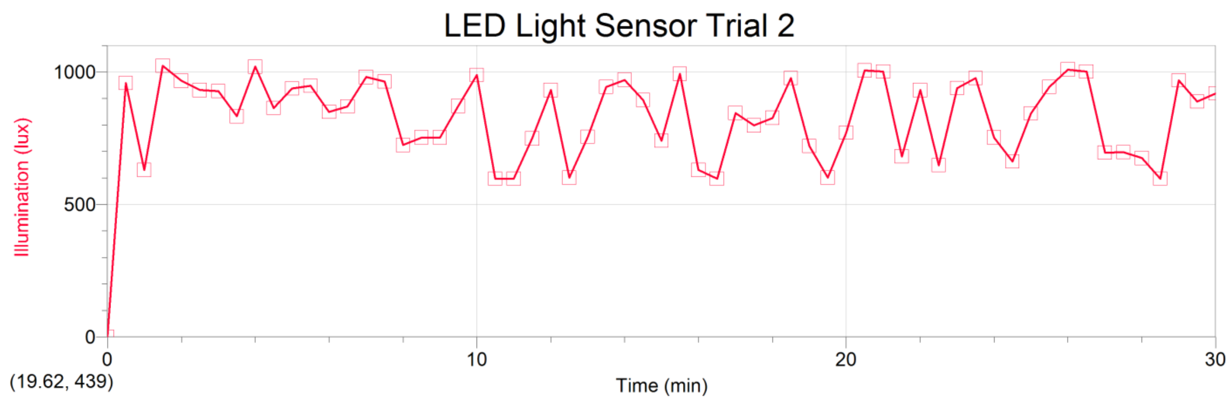

Figure H-36 Graph 5

Table H-26: LED Illumination Versus Time Trial 3

Time (Mins)	Illumination (lux)
0	0
0.5	912.9199219
1	1011.4151
1.5	793.8995361
2	1009.34967
2.5	1003.153381
3	660.5502319
3.5	832.8845215
4	594.9728394
4.5	956.0357666
5	917.0507813
5.5	933.4451294
6	722.1258545
6.5	765.2416992
7	921.1816406
7.5	857.5405884
8	857.5405884
8.5	785.7669067
9	958.1011963
9.5	939.6414185
10	910.8544922
10.5	951.9049072
11	728.3221436
11.5	806.2921143
12	769.3725586
12.5	713.8641357
13	672.9428101
13.5	929.31427

Time (Mins)	Illumination (lux)
14	631.892395
14.5	605.1708984
15	674.8791504
15.5	1003.153381
16	738.5202026
16.5	592.9074097
17	658.4848022
17.5	863.7368774
18	1007.284241
18.5	923.2470703
19	709.8623657
19.5	609.3017578
20	601.0400391
20.5	917.0507813
21	703.6660767
21.5	914.9853516
22	958.1011963
22.5	800.0958252
23	783.7014771
23.5	941.7068481
24	1009.34967
24.5	597.038269
25	597.038269
25.5	1003.153381
26	722.1258545
26.5	1007.284241
27	888.263855
27.5	919.1162109
28	793.8995361
28.5	951.9049072
29	822.6864624
29.5	960.166626
30	609.3017578

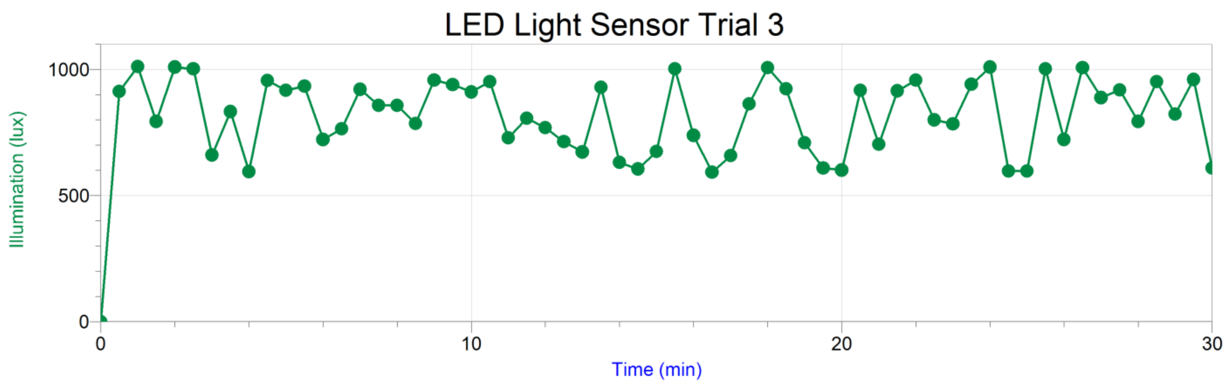

Figure H-37 Graph 6

CFL Temperature

Table H-27:CFL Temperature Versus Time Trial 1

Time (Mins)	Temperature (F)
0	74.72889939
0.5	74.68708066
1	74.72889939
1.5	75.14437517
2	75.30895135
2.5	75.64325481
3	75.55968776
3.5	76.016629
4	76.34814545
4.5	76.67959608
5	77.01099135
5.5	77.21711153
6	77.34234168
6.5	77.42582568
7	77.96582114
7.5	78.00494916
8	78.37796237
8.5	78.41969767
9	78.54490357
9.5	79.08486603
10	79.08486603
10.5	79.33268981
11	79.54139528
11.5	79.74750513
12	80.16238366
12.5	80.16238366
13	80.32679141
13.5	80.16238366

Time (Mins)	Temperature (F)
14	80.45206401
14.5	80.70263637
15	80.74179179
15.5	80.53558397
16	80.74179179
16.5	80.82532669
17	80.95063785
17.5	81.03418473
18	81.03418473
18.5	81.40759926
19	81.6557351
19.5	81.6557351
20	81.44938686
20.5	81.86473445
21	81.94573282
21.5	81.73932997
22	81.40759926
22.5	81.69753174
23	81.90392641
23.5	81.82293131
24	81.86473445
24.5	82.0711624
25	81.94573282
25.5	82.0711624
26	82.0711624
26.5	82.23842682
27	82.15479098
27.5	81.82293131
28	82.27763367
28.5	82.0711624
29	82.36128048
29.5	82.31945613
30	82.40310676

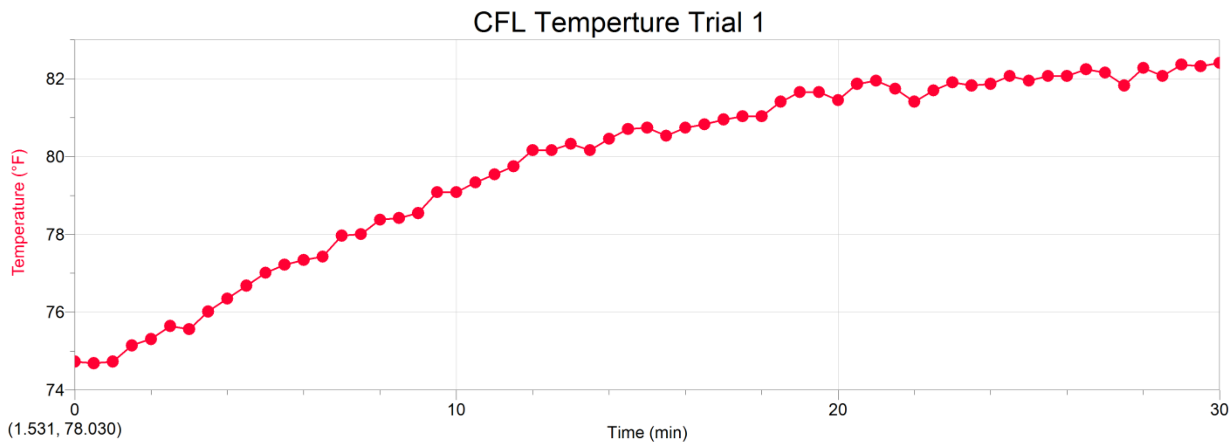

Figure H-38 Graph 7

Table H-28: CFL Temperature Versus Time Trial 2

Time (Mins)	Temperature (F)
0	73.35562349
0.5	73.39751272
1	73.56504434
1.5	73.81365188
2	74.10402628
2.5	74.22956062
3	74.68708066
3.5	74.97716043
4	74.85434448
4.5	75.51790209
5	75.7659838
5.5	75.80776122
6	76.51257342
6.5	76.51257342
7	76.55433048
7.5	76.80485378
8	77.05273853
8.5	77.30059887
9	77.63191846
9.5	77.55104792
10	77.84060999
10.5	78.0466855
11	78.17189341
11.5	78.83444482
12	78.41969767
12.5	79.00139125
13	79.00139125

Time (Mins)	Temperature (F)
13.5	78.67010991
14	79.29095011
14.5	79.33268981
15	79.20747193
15.5	79.95363059
16	79.70576018
16.5	79.83099697
17	79.95363059
17.5	79.99537964
18	80.16238366
18.5	80.24589064
19	79.99537964
19.5	80.20413672
20	80.32679141
20.5	80.28764545
21	80.70263637
21.5	80.70263637
22	80.66087166
22.5	80.66087166
23	80.74179179
23.5	80.95063785
24	81.03418473
24.5	81.03418473
25	81.03418473
25.5	80.90886626
26	81.2404632
26.5	81.19868266
27	81.32402841
27.5	81.32402841
28	81.36581312
28.5	81.40759926
29	81.53035454
29.5	81.61394003
30	81.6557351

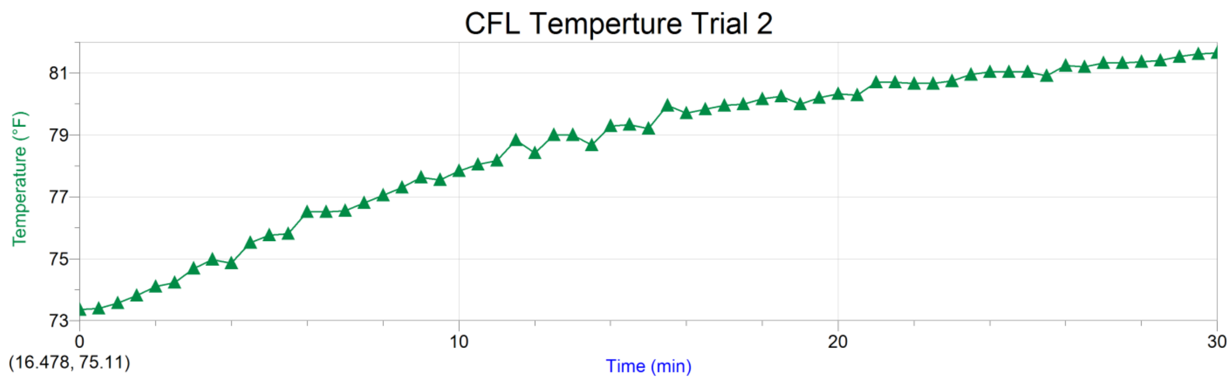

Figure H-39 Graph 8

Table H-29: CFL Temperature Versus Time Trial 3

Time (Mins)	Temperature (F)
0	76.55433048
0.5	76.59608659
1	76.84399528
1.5	76.4708154
2	77.05273853
2.5	76.96924345
3	77.05273853
3.5	77.01099135
4	77.4675669
4.5	77.4675669
5	77.59278775
5.5	77.92408436
6	78.2971001
6.5	78.50316825
7	78.2971001
7.5	78.46143295
8	79.00139125
8.5	79.00139125
9	79.20747193
9.5	79.20747193
10	79.49965319
10.5	79.74750513
11	79.70576018
11.5	79.70576018
12	79.91449153
12.5	80.16238366
13	80.20413672
13.5	80.20413672
14	80.24589064

Time (Mins)	Temperature (F)
14.5	80.49382349
15	80.66087166
15.5	80.61910803
16	80.95063785
16.5	81.03418473
17	80.78355866
17.5	80.99241066
18	80.99241066
18.5	81.03418473
19	81.03418473
19.5	81.19868266
20	80.99241066
20.5	81.44938686
21	81.07596007
21.5	81.53035454
22	81.07596007
22.5	81.28224511
23	81.40759926
23.5	81.44938686
24	81.44938686
24.5	81.40759926
25	81.32402841
25.5	81.6557351
26	81.6557351
26.5	81.6557351
27	81.73932997
27.5	81.53035454
28	81.61394003
28.5	81.86473445
29	81.69753174
29.5	81.82293131
30	81.86473445

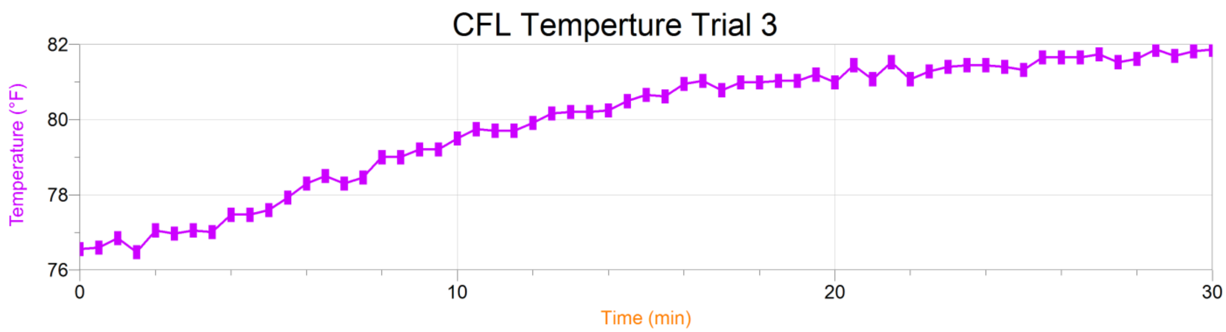

Figure H-40 Graph 9

LED Temperature

Table H-30: LED Temperature Versus Time Trial 1

Time (Mins)	Temperature (F)
0	80.57734548
0.5	80.70263637
1	80.90886626
1.5	81.03418473
2	81.2404632
2.5	81.32402841
3	81.40759926
3.5	81.61394003
4	81.73932997
4.5	81.86473445
5	81.94573282
5.5	82.02935079
6	82.15479098
6.5	82.19660798
7	82.27763367
7.5	82.36128048
8	82.44493497
8.5	82.5285973
9	82.65410583
9.5	82.65410583
10	82.77701757
10.5	82.73517324
11	82.8607126
11.5	82.8607126
12	82.90256334
12.5	82.94441627
13	83.02812876
13.5	83.10923379
14	83.06737207
14.5	83.15109779

Time (Mins)	Temperature (F)
15	83.15109779
15.5	83.19296409
16	83.31857704
16.5	83.2767037
17	83.31857704
17.5	83.36045276
18	83.36045276
18.5	83.36045276
19	83.40233089
19.5	83.40233089
20	83.44421144
20.5	83.525362
21	83.48347668
21.5	83.525362
22	83.48347668
22.5	83.525362
23	83.525362
23.5	83.6091401
24	83.6091401
24.5	83.6091401
25	83.6091401
25.5	83.65103294
26	83.69292832
26.5	83.65103294
27	83.69292832
27.5	83.69292832
28	83.73482626
28.5	83.73482626
29	83.73482626
29.5	83.73482626
30	83.73482626

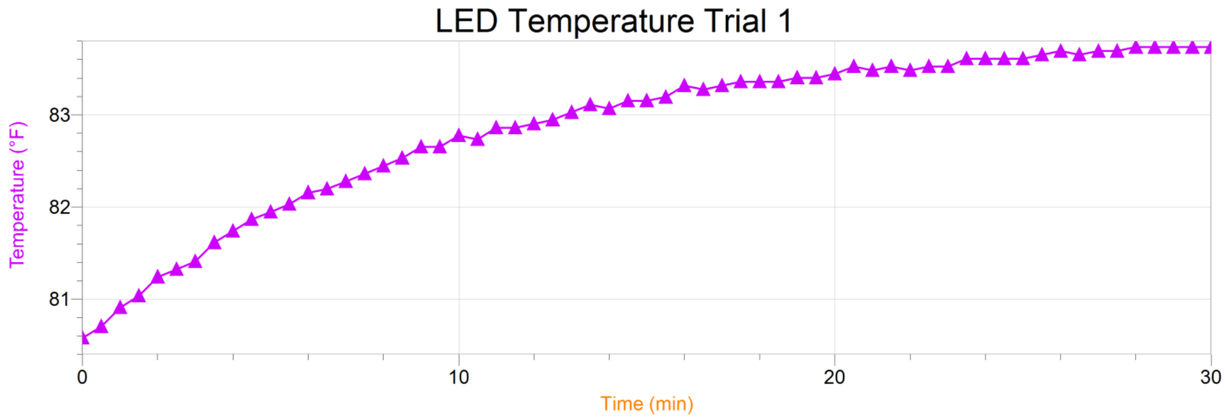

Figure H-41 Graph 10

Table H-31: LED Temperature Versus Time Trial 2

Time (Mins)	Temperature (F)
0	76.63784179
0.5	76.76310206
1	76.88574544
1.5	77.17797601
2	77.38408394
2.5	77.63191846
3	77.88234731
3.5	78.13015761
4	78.2971001
4.5	78.54490357
5	78.87618109
5.5	79.08486603
6	79.20747193
6.5	79.41617054
7	79.54139528
7.5	79.78925072
8	79.95363059
8.5	80.12063144
9	80.28764545
9.5	80.49382349
10	80.53558397
10.5	80.57734548
11	80.74179179
11.5	80.86709588
12	80.95063785
12.5	81.03418473
13	81.07596007

Time (Mins)	Temperature (F)
13.5	81.36581312
14	81.28224511
14.5	81.40759926
15	81.49117593
15.5	81.53035454
16	81.57214652
16.5	81.6557351
17	81.73932997
17.5	81.82293131
18	81.86473445
18.5	81.90392641
19	81.98754094
19.5	81.98754094
20	82.0711624
20.5	82.11297579
21	82.15479098
21.5	82.15479098
22	82.36128048
22.5	82.27763367
23	82.36128048
23.5	82.31945613
24	82.40310676
24.5	82.48676514
25	82.48676514
25.5	82.44493497
26	82.5285973
26.5	82.5285973
27	82.65410583
27.5	82.65410583
28	82.65410583
28.5	82.65410583
29	82.69333102
29.5	82.73517324
30	82.73517324

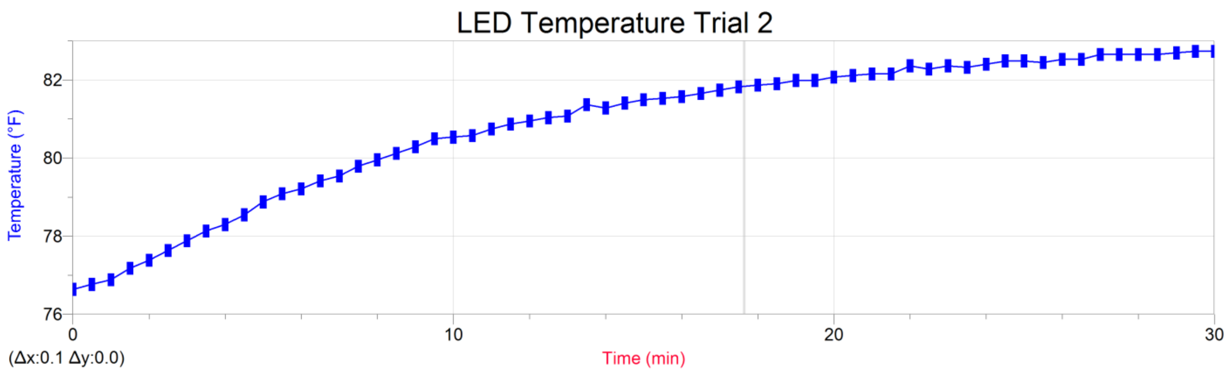

Figure H-42 Graph 11

Table H-32: LED Temperature Versus Time Trial 3

Time (Mins)	Temperature (F)
0	76.18109093
0.5	76.18109093
1	76.26462036
1.5	76.4290564
2	76.67959608
2.5	76.80485378
3	77.09448502
3.5	77.38408394
4	77.50930765
4.5	77.71539614
5	77.96582114
5.5	78.13015761
6	78.37796237
6.5	78.54490357
7	78.83444482
7.5	79.00139125
8	79.16573341
8.5	79.33268981
9	79.45791162
9.5	79.62227212
10	79.70576018
10.5	79.83099697
11	79.99537964
11.5	80.12063144
12	80.20413672
12.5	80.28764545
13	80.41030552
13.5	80.53558397
14	80.61910803

Time (Mins)	Temperature (F)
14.5	80.74179179
15	80.82532669
15.5	80.86709588
16	80.99241066
16.5	81.03418473
17	81.19868266
17.5	81.15690348
18	81.19868266
18.5	81.28224511
19	81.36581312
19.5	81.49117593
20	81.49117593
20.5	81.53035454
21	81.57214652
21.5	81.6557351
22	81.6557351
22.5	81.73932997
23	81.73932997
23.5	81.82293131
24	81.73932997
24.5	81.86473445
25	81.86473445
25.5	81.94573282
26	81.98754094
26.5	81.98754094
27	82.02935079
27.5	82.0711624
28	82.0711624
28.5	82.11297579
29	82.15479098
29.5	82.15479098
30	82.19660798

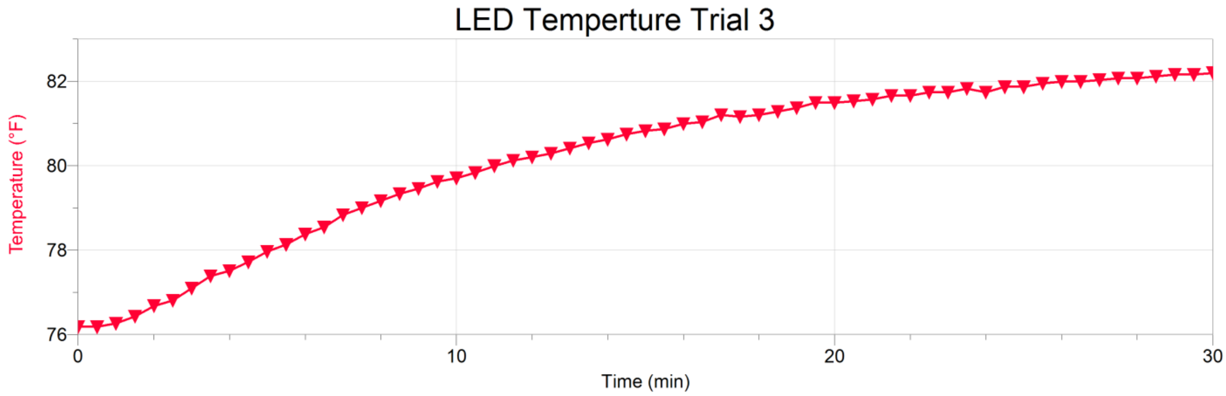

Figure H-43 Graph 12

CFL Temperature Versus Illuminance

Table H-33:CFL Temperature Versus Illumination Trial 1

Temperature (F)	Illumination (lux)
79.62227212	0
79.41617054	677.0736694
79.33268981	802.2903442
79.41617054	867.9968262
79.08486603	851.602478
79.33268981	824.8809814
79.33268981	693.5971069
79.49965319	755.0436401
79.49965319	777.6342773
79.66401585	716.0586548
79.70576018	804.3557739
79.70576018	800.2249146
79.83099697	798.1594849
79.83099697	705.8605957
79.91449153	742.7801514
80.03712945	790.0268555
80.12063144	734.5184326
80.16238366	802.2903442
80.20413672	837.1444702
80.32679141	769.5016479
80.49382349	845.406189
80.28764545	837.1444702
80.53558397	847.4716187
80.61910803	812.6174927
80.66087166	779.699707
80.61910803	759.1744995
80.70263637	705.8605957

Temperature (F)	Illumination (lux)
80.74179179	837.1444702
80.82532669	755.0436401
80.95063785	808.4866333
81.03418473	757.1090698
80.86709588	837.1444702
80.99241066	794.0286255
81.03418473	849.5370483
81.03418473	849.5370483
81.03418473	851.602478
81.19868266	724.3203735
81.19868266	685.3353882
81.28224511	796.0940552
81.19868266	763.3053589
81.49117593	841.2753296
81.03418473	808.4866333
81.19868266	851.602478
81.28224511	781.7651367
81.32402841	697.598877
81.40759926	705.8605957
81.6557351	812.6174927
81.49117593	814.553833
81.40759926	820.7501221
81.49117593	794.0286255
81.49117593	783.8305664
81.49117593	790.0268555
81.49117593	691.5316772
81.53035454	720.1895142
81.6557351	839.2098999
81.69753174	843.3407593
81.40759926	845.406189
81.61394003	748.9764404
81.78112982	792.0922852
81.69753174	804.3557739
81.40759926	837.1444702

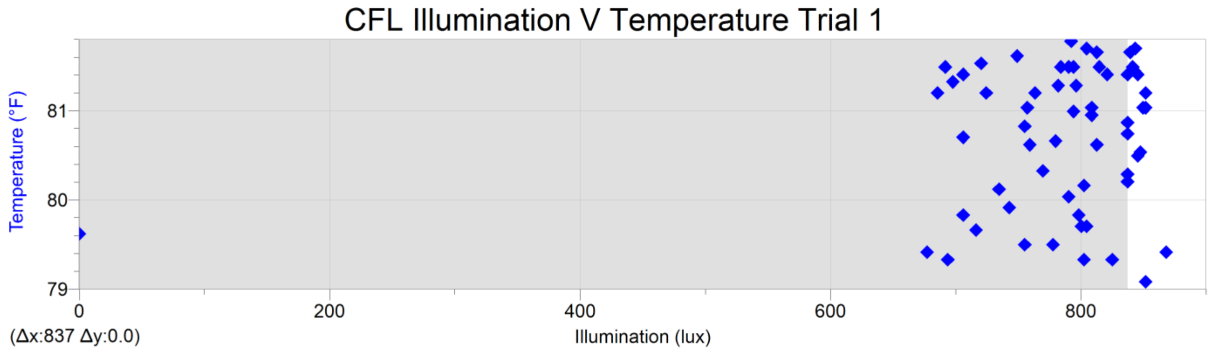

Figure H-44 Graph 13

Table H-34: CFL Temperature Versus Illumination Trial 2

Temperature (F)	Illumination (lux)
73.02303483	0
73.19065949	426.7694092
73.06494506	713.9932251
73.48128354	859.7351074
73.69066714	755.0436401
73.85551441	835.0790405
73.98108821	872.1276855
74.10402628	876.1294556
74.51978668	843.3407593
74.51978668	878.1948853
74.85434448	849.5370483
75.22797254	837.1444702
75.35074455	853.5388184
75.55968776	771.5670776
75.93308567	841.2753296
76.05578826	738.649292
76.2228562	691.5316772
76.38990642	765.3707886
76.67959608	730.5166626
76.63784179	724.3203735
77.01099135	849.5370483
77.09448502	824.8809814
77.21711153	835.0790405
77.34234168	837.1444702
77.63191846	751.0418701
77.75713443	792.0922852
77.84060999	814.553833
77.84060999	855.604248
77.96582114	713.9932251

Temperature (F)	Illumination (lux)
78.21362909	835.0790405
78.21362909	851.602478
78.33883549	826.9464111
78.41969767	845.406189
78.50316825	773.503418
78.67010991	740.7147217
79.00139125	730.5166626
79.00139125	837.1444702
79.08486603	742.7801514
79.00139125	861.8005371
79.20747193	794.0286255
79.29095011	794.0286255
79.20747193	831.0772705
79.41617054	802.2903442
79.66401585	841.2753296
79.49965319	755.0436401
79.49965319	804.3557739
79.66401585	687.4008179
79.70576018	726.3858032
79.83099697	851.602478
79.74750513	829.0118408
79.70576018	853.5388184
79.74750513	845.406189
79.8727439	829.0118408
79.91449153	703.795166
79.91449153	730.5166626
80.03712945	857.6696777
80.07888004	738.649292
80.07888004	751.0418701
79.91449153	859.7351074
80.20413672	853.5388184
80.07888004	859.7351074

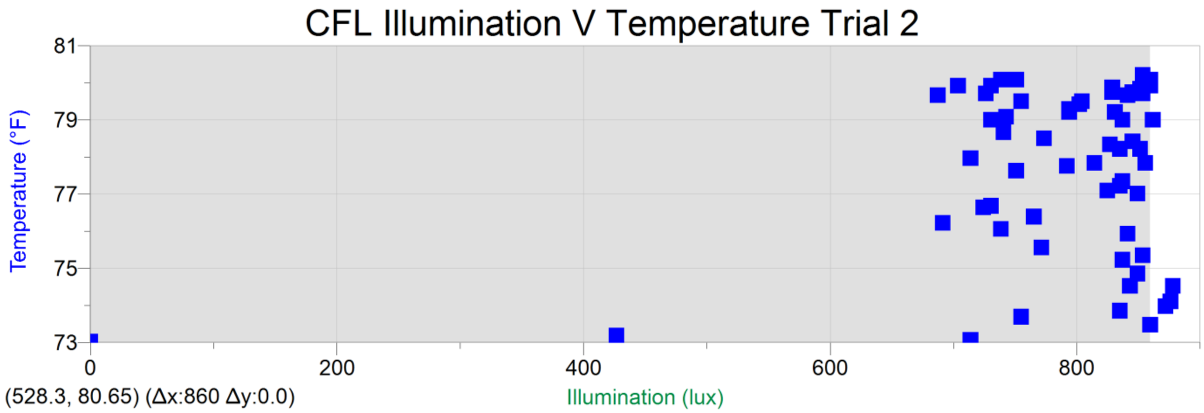

Figure H-45 Graph 14

Table H-35:CFL Temperature Versus Illumination Trial 3

Temperature (F)	Illumination (lux)
80.49382349	0
80.45206401	779.699707
80.41030552	761.2399292
80.36854799	724.3203735
80.49382349	853.5388184
80.36854799	804.3557739
80.45206401	861.8005371
80.41030552	728.4512329
80.45206401	773.503418
80.36854799	734.5184326
80.49382349	820.7501221
80.41030552	783.8305664
80.41030552	853.5388184
80.61910803	783.8305664
80.53558397	728.4512329
80.66087166	689.4662476
80.66087166	697.598877
80.66087166	722.2549438
80.61910803	792.0922852
80.61910803	695.5334473
80.74179179	831.0772705
80.78355866	796.0940552
80.74179179	822.8155518
80.78355866	759.1744995
80.74179179	765.3707886
80.70263637	849.5370483
80.90886626	859.7351074
80.82532669	746.9110107

Temperature (F)	Illumination (lux)
80.95063785	687.4008179
80.82532669	744.8455811
80.95063785	826.9464111
80.95063785	810.552063
80.82532669	843.3407593
80.95063785	802.2903442
80.95063785	790.0268555
80.99241066	806.4212036
80.90886626	783.8305664
81.07596007	841.2753296
80.86709588	845.406189
80.99241066	736.5838623
81.03418473	779.699707
80.99241066	779.699707
81.07596007	718.1240845
80.82532669	841.2753296
81.07596007	857.6696777
80.99241066	837.1444702
81.15690348	685.3353882
81.07596007	816.6192627
81.03418473	794.0286255
80.86709588	806.4212036
80.99241066	841.2753296
81.2404632	839.2098999
81.07596007	726.3858032
81.11512562	709.9914551
80.99241066	843.3407593
81.2404632	853.5388184
81.07596007	738.649292
81.03418473	831.0772705
81.19868266	849.5370483
81.28224511	738.649292
81.2404632	687.4008179

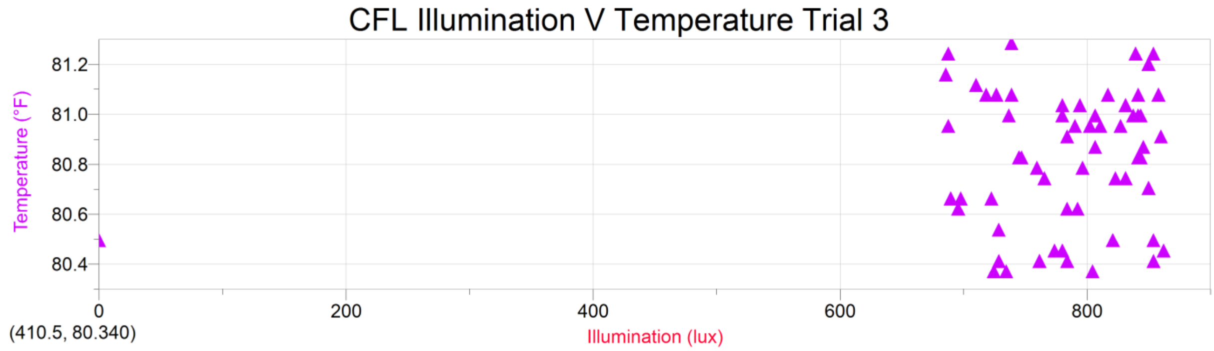

Figure H-46 Graph 15

LED Illumination Versus Temperature

Table H-36: LED Temperature Versus Illumination Trial 1

Temperature (F)	Illumination (lux)
76.34814545	0
76.2228562	911.1126709
76.18109093	673.0718994
76.2228562	798.1594849
76.26462036	1081.381531
76.30638344	849.5370483
76.38990642	929.5724487
76.4708154	976.6900635
76.59608659	945.9667969
76.55433048	613.5617065
76.63784179	1034.134827
76.67959608	607.3654175
76.84399528	707.9260254
76.84399528	997.215271
76.88574544	599.1036987
76.96924345	790.0268555
77.01099135	771.5670776
77.05273853	1011.544189
77.13623084	671.0064697
77.13623084	748.9764404
77.2588555	666.8756104
77.34234168	761.2399292
77.42582568	913.0490112
77.38408394	613.5617065
77.4675669	1034.134827
77.55104792	607.3654175
77.59278775	621.6943359
77.63191846	590.9710693

Temperature (F)	Illumination (lux)
77.67365749	989.0826416
77.71539614	593.036499
77.75713443	999.2807007
77.84060999	1023.936768
77.88234731	837.1444702
77.88234731	615.4980469
78.00494916	629.9560547
78.00494916	1009.607849
78.0466855	615.4980469
78.0466855	882.3257446
78.13015761	590.9710693
78.17189341	1007.542419
78.25536464	865.9313965
78.21362909	597.038269
78.37796237	911.1126709
78.33883549	954.0994263
78.2971001	664.8101807
78.37796237	588.9056396
78.41969767	720.1895142
78.50316825	997.215271
78.54490357	593.036499
78.54490357	999.2807007
78.58663894	960.2957153
78.62837438	984.9517822
78.62837438	621.6943359
78.67010991	590.9710693
78.83444482	915.1144409
78.87618109	594.9728394
78.87618109	919.2453003
78.95965429	902.8509521
78.91791757	824.8809814
78.95965429	980.8209229
79.00139125	839.2098999

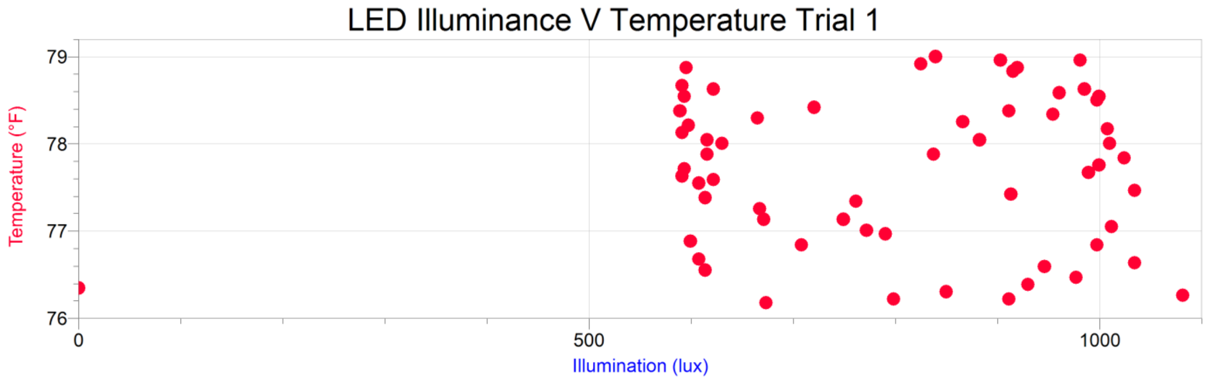

Figure H-47 Graph 16

Table H-37: LED Temperature Versus Illumination Trial 2

Temperature (F)	Illumination (lux)
72.88680755	0
72.88680755	681.0754395
73.01255685	818.555603
73.13828141	1044.203796
73.26398183	619.4998169
73.34515079	695.4043579
73.55457478	1114.041138
73.63832696	668.8119507
73.71945263	670.8773804
73.88690979	933.4451294
73.9706245	986.7590332
74.05433021	1050.400085
74.21910016	999.1516113
74.30278013	1050.400085
74.42828453	849.2788696
74.47011527	687.2717285
74.6348046	668.8119507
74.71844488	1040.202026
74.76026221	609.3017578
74.92490019	1075.056152
75.00851527	876.0003662
75.09212347	687.2717285
75.21752323	910.8544922
75.29850281	605.1708984
75.38208844	802.1612549
75.46566794	623.6306763
75.54924148	898.5910034
75.67459099	935.5105591

Temperature (F)	Illumination (lux)
75.75553923	902.7218628
75.83909342	1064.729004
75.9226424	1054.530945
76.00618635	615.4980469
76.04795649	773.3743286
76.12888275	958.1011963
76.25417943	656.4193726
76.29594277	1031.940308
76.37946628	999.1516113
76.46298566	605.1708984
76.502134	1001.217041
76.58564765	685.2062988
76.66915759	613.4326172
76.71091122	640.0250244
76.79441593	701.600647
76.87791734	900.6564331
76.95880636	1046.269226
77.0423018	654.4830322
77.08404846	629.8269653
77.12579444	966.2338257
77.20928447	890.3292847
77.25102855	627.7615356
77.33190603	597.038269
77.41539029	703.6660767
77.41539029	603.1054688
77.5406129	734.3893433
77.5406129	594.9728394
77.58235284	935.5105591
77.70496151	1009.34967
77.70496151	697.4697876
77.78843792	1042.138367
77.78843792	1007.284241
77.87191301	621.5652466

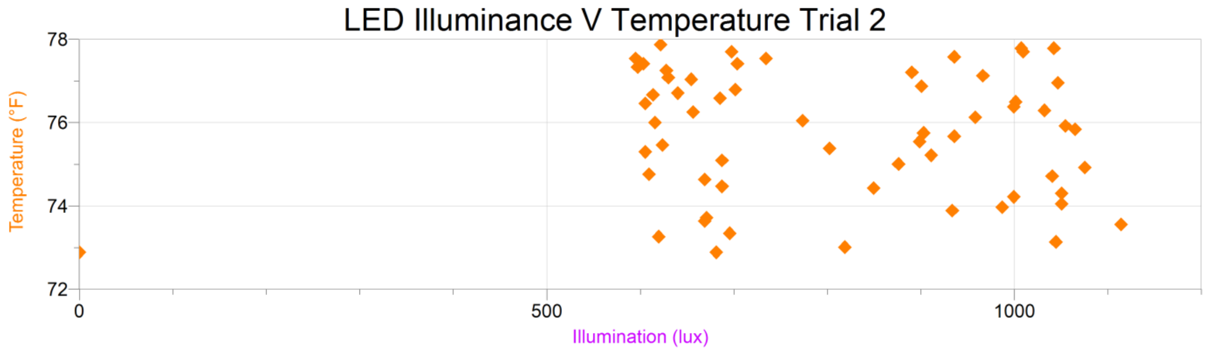

Figure H-48 Graph 17

Table H-38: LED Temperature Versus Illumination Trial 3

Temperature (F)	Illumination (lux)
77.70496151	0
77.62409235	865.8023071
77.66583146	705.7315063
77.70496151	949.8394775
77.66583146	590.84198
77.70496151	592.9074097
77.78843792	1015.545959
77.78843792	586.7111206
77.91365012	808.3575439
77.91365012	598.9746094
77.99712357	685.2062988
78.03885995	1021.613159
78.08059613	640.0250244
78.11972363	1019.676819
78.20319518	586.7111206
78.24493076	1019.676819
78.24493076	929.31427
78.32840165	681.0754395
78.37013699	619.4998169
78.4118723	972.4301147
78.45360759	999.1516113
78.53446974	728.3221436
78.57620509	685.2062988
78.61794051	1017.611389
78.61794051	750.9127808
78.70141163	847.3425293
78.70141163	947.7740479
78.86835552	793.8995361
78.90748343	621.5652466

Temperature (F)	Illumination (lux)
78.99095699	919.1162109
79.03269416	837.0153809
78.99095699	939.6414185
79.07443162	956.0357666
79.07443162	904.7872925
79.11616938	627.7615356
79.11616938	582.5802612
79.19964593	933.4451294
79.24138475	586.7111206
79.24138475	771.3088989
79.28312396	800.0958252
79.36399487	695.4043579
79.32225485	582.5802612
79.36399487	997.0861816
79.40573535	771.3088989
79.40573535	787.8323364
79.4474763	592.9074097
79.48921775	664.6810913
79.5309597	976.5609741
79.5309597	584.6456909
79.5727022	594.9728394
79.61444524	867.7386475
79.61444524	976.5609741
79.65618886	621.5652466
79.69793308	917.0507813
79.69793308	637.9595947
79.69793308	642.0904541
79.73706884	997.0861816
79.73706884	1009.34967
79.73706884	820.6210327
79.77881426	882.1966553
79.82056034	900.6564331

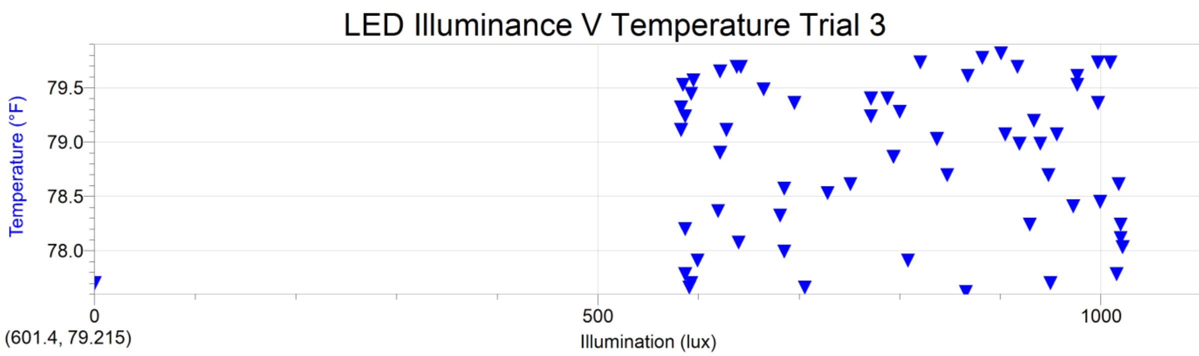

Figure H-49 Graph 18

Now let's compare the data.

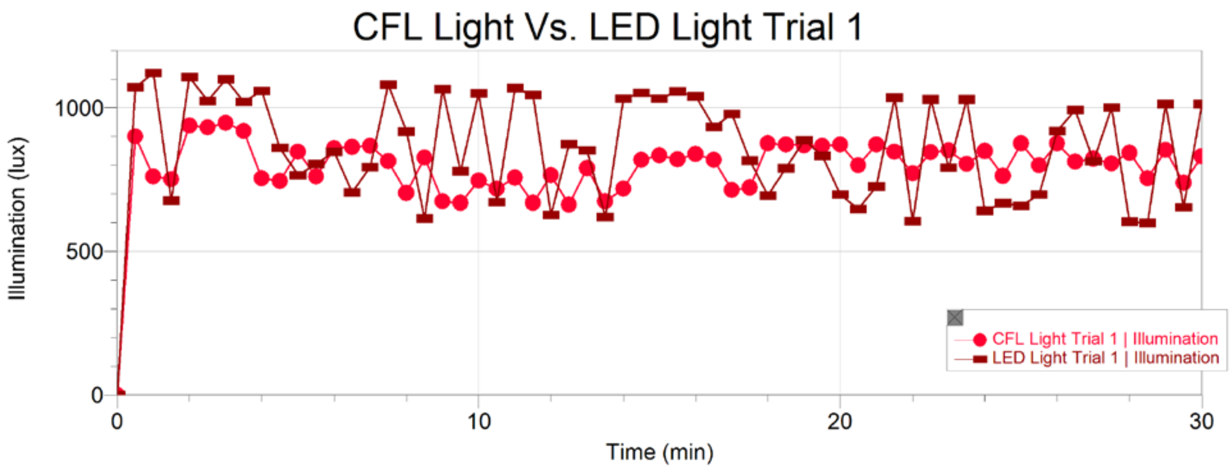

Figure H-50 Illumination Trial 1 Graph 19

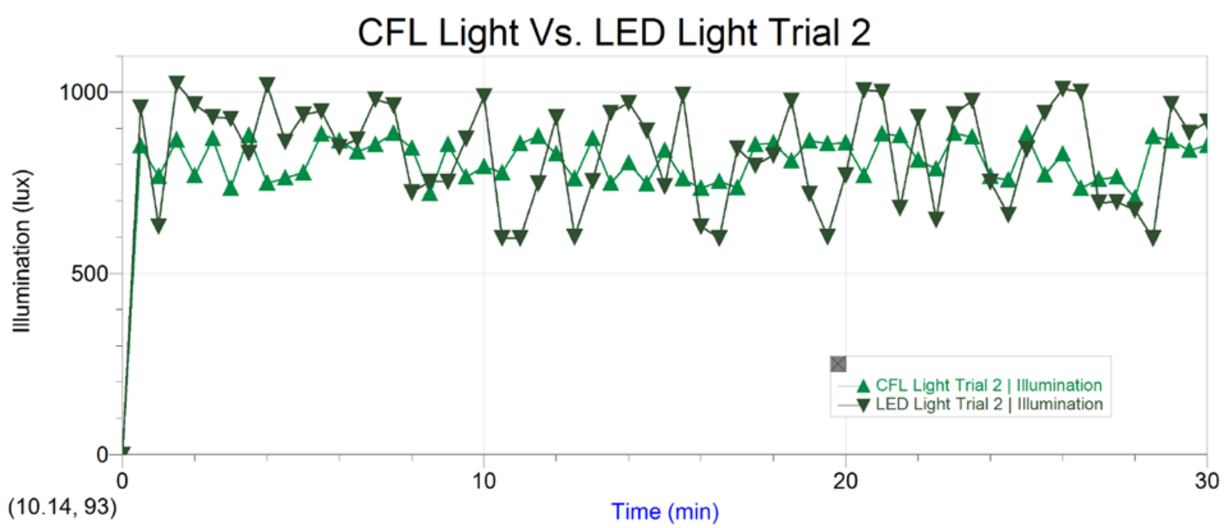

Figure H-51 Illumination Trial 2 Graph 20

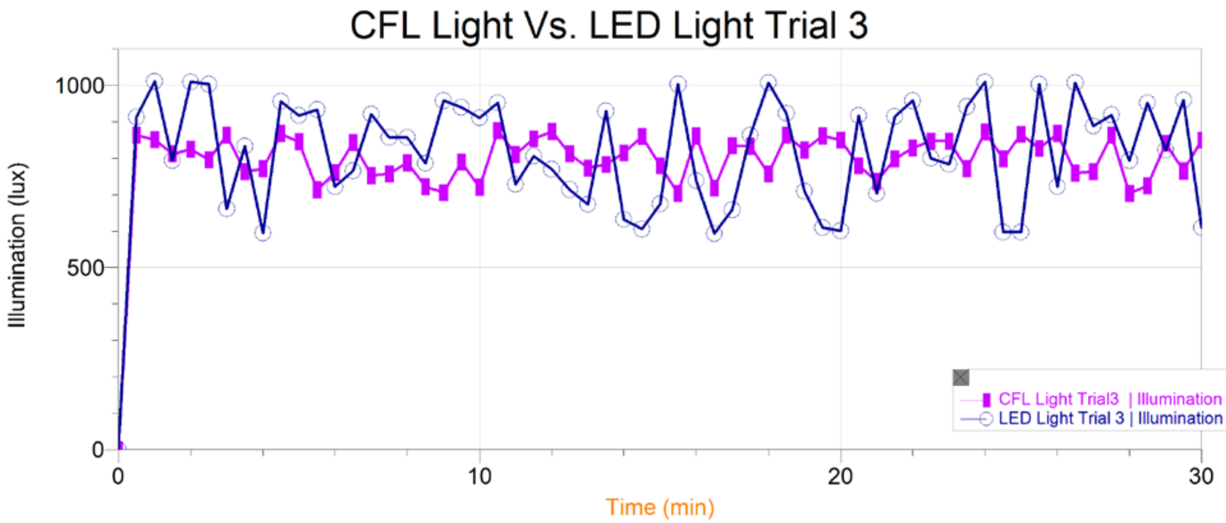

Figure H-52 Illumination Trial 3 Graph 20

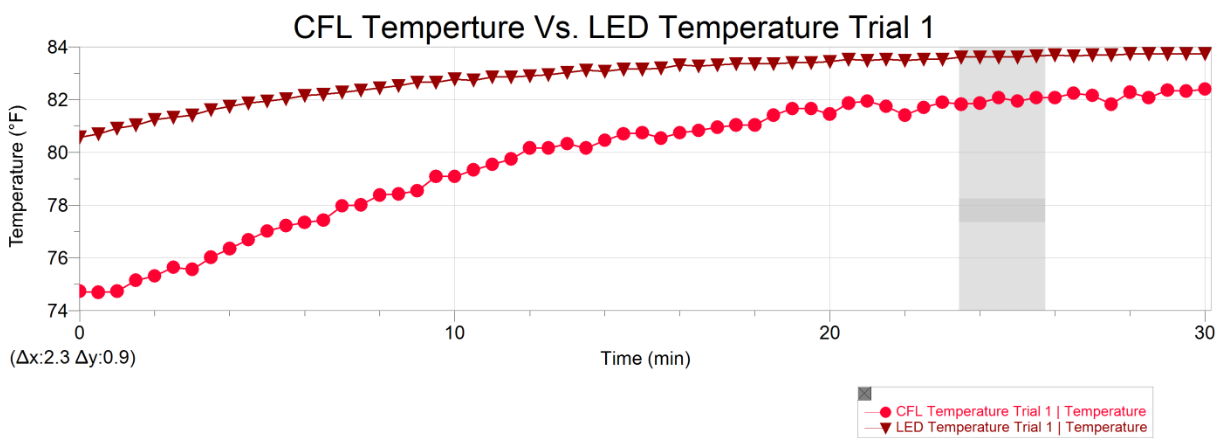

Figure H-53 Temperature Trial 1 Graph 21

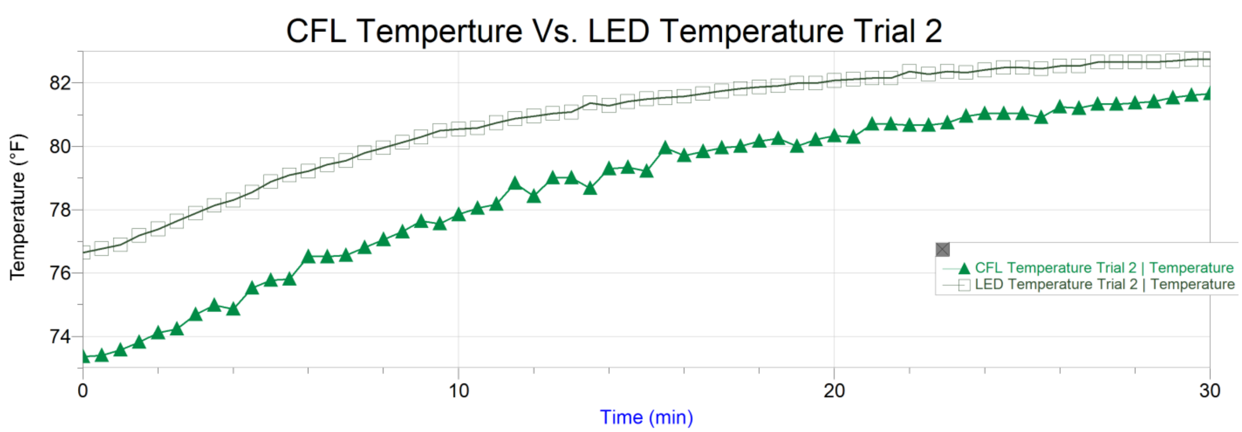

Figure H-54 Temperature Trial 2 Graph 22

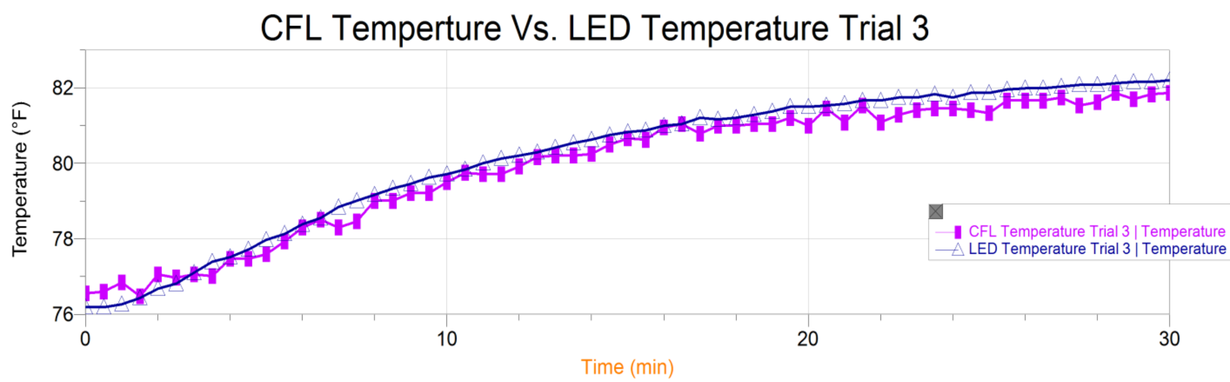

Figure H-55 Temperature Trial 3 Graph 23

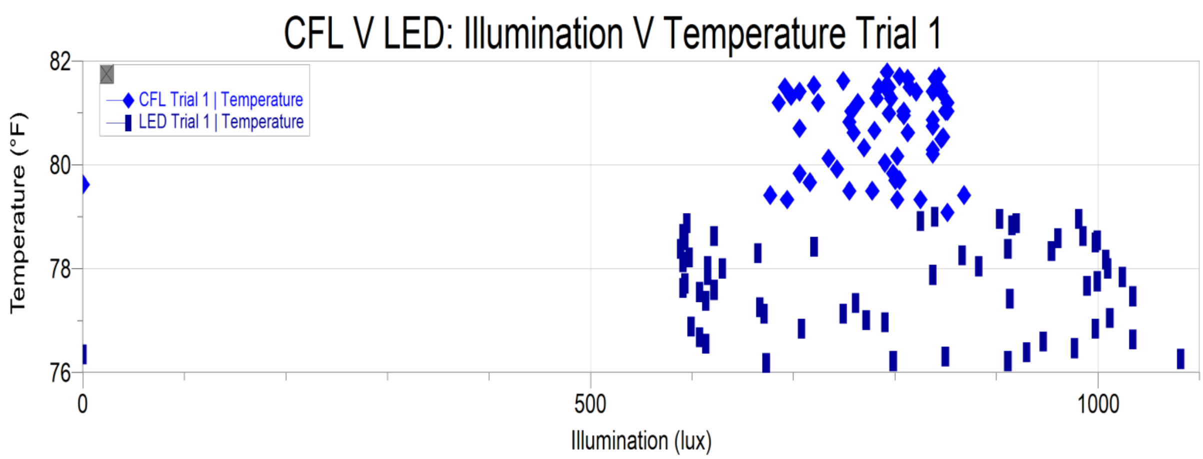

Figure H-56 Temperature versus Illumination Trial 1Graph 24

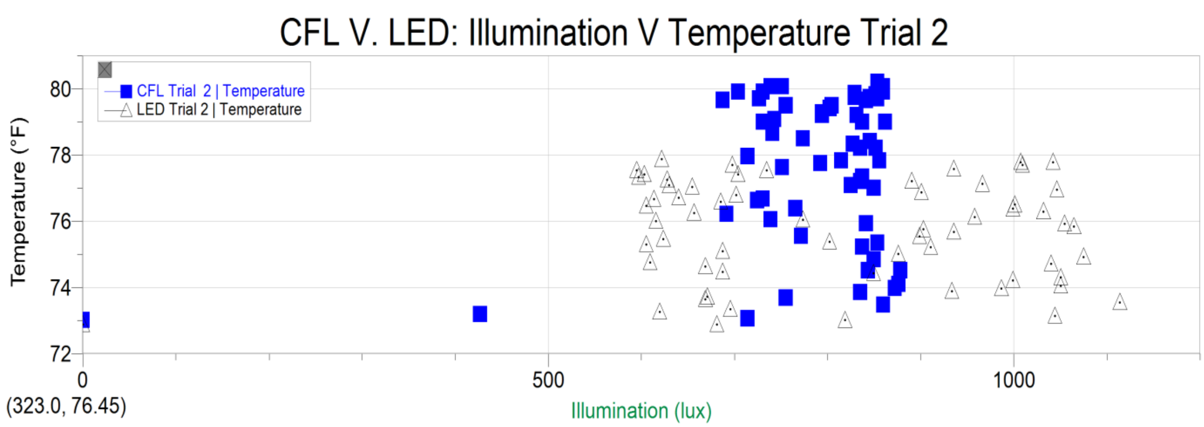

Figure H-57 Temperature versus Illumination Trial 2 Graph 26

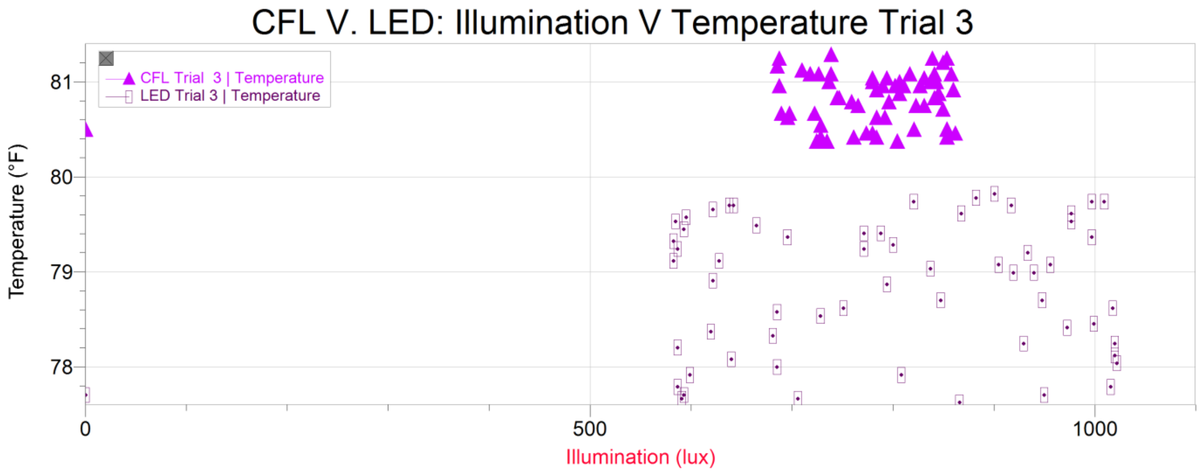

Figure H-58 Temperature versus Illumination Trial 3 Graph 27

H4.4 Discussion

The first thing that was noticed with the data presented was that once the light got bright that the amount of lux never stabilizes. It was expected to gradually grow in intensity and then stabilize out for the rest of the trial.

In table H-21, the first trial of the CFL illuminance versus time trials, the highest amount of illuminance reached was 947.7740479 lux and was reached at 3 minutes. The lowest amount of lux was 662.6156616 lux and was reached at 12.5 minutes. The range in the amount of illuminance is 285 and had four matches in data. A match is when the amount of lux is repeated at a different data point. In table H-22, the second trial of the CFL illuminance versus time trials, the highest amount of illuminance reached was 886.3275146 lux and was reached at 7.5 and 23 minutes. The lowest amount of lux was 707.796936 lux and was reached at 28 minutes. The range in the amount of illuminance is 179 and had 12 matches in data including the highest number reached was among those matches. In table H-23, the third trial of the CFL illuminance versus time trials, the highest amount of illuminance reached was 867.7386475 lux and was reached at 4.5 and 26 minutes. The lowest amount of lux was 703.6660767 lux and was reached at 15.5 and 28 minutes. The range in the amount of illuminance is 164 and had 12 matches in data including the highest and lowest amount of illuminance.

In table H-24, the first trial of the LED illuminance versus time trials, the highest amount of illuminance reached was 1122.173767 lux and was reached at 1 minute. The lowest amount of lux was 598.9746094 lux and was reached at 28.5 minutes. The range in the amount of illuminance is 524 and had no matches in data it just fluxuated constantly. In table H-25, the second trial of the LED illuminance versus time trials, the highest amount of illuminance reached was 1023.678589 lux and was reached at 1.5 minute. The lowest amount of lux was 597.038269 lux and was reached at 10.5, 11, 16.5, and 28.5 minutes. The range in the amount of illuminance is 426 and had 1 match in the data and it repeated itself four times. In table H-26, the third trial of the LED illuminance versus time trials, the highest amount of illuminance reached was 1009.34967 lux and was reached at 2 and 24 minutes.

The lowest amount of lux was 592.9074097 lux and was reached at 16.5 minutes. The range in the amount of illuminance is 417 and had 8 matches in the data and there were two special occureneces. At 7.5 and 8 minutes the same amount of lux was recorded and the same thing happened at 24.5 and 25 minutes. Table H-26 is the only illuminence trial that had a data

point repeat. Also in this table it is noticed that there are a few sudden drops in illuminance and a few sudden rises. At 2.5 minutes the amount of lux recorded was 1003.153381 lux and at 3 minutes it was 660.5502319 lux.

The temperature percentage of change varied slightly between trials for the light bulbs but not by a whole lot. The CFL temperature trials in tables H-27 through H-29 show the following percentage of change for temperature: 1st trial – 13.3%, 2nd trial – 12.3%, and 3rd trial – 6.5%. the CFL bulb never reached a temperature greater the 82 degrees Fahrenheit. The LED temperature trials in tables H-27 through H-29 show the following percentage of change for temperature: 1st trial – 3.7%, 2nd trial – 7.8%, and 3rd trial – 7.8%. The Led bulb only temperature only changed at most by 6 degrees. Even though in some of the trials the LED reached a higher temperature than the CFL the percentage of change is still lower. This is probably due to human error by not letting the temperature probe cool off to a lower level.

The data showed that there was no direct correlation between temperature and illuminance. As the graphs and raw data was analyzed looking for a pattern, none arose. In Table H-33, the first trial of the CFL illuminance versus temperature trial , the highest amount of illuminance reached was 867.9968262 lux and was reached at a temperature of 79.41617054 degrees Fahrenheit. The lowest amount of lux was 685.3353882 lux and was reached at a temperature of 81.19868266 degrees Fahrenheit. The most interesting detail about this data is that a lower amount of lux recorded can also produce a higher temperature. The highest temperature reached in this trial was 81.78112982 degrees Fahrenheit, but the amount of lux recorded was 792.0922852 lux. In table H-34, the second trial of the CFL illuminance versus temperature trial, the highest amount of lux recorded was recorded at a higher temperature that the lowest amount of lux recorded. The highest amount of lux recorded was 878.1948853 lux at 74.51978668 degrees Fahrenheit. The lowest amount of lux recorded was 426.7694092 at 73.19065949 degrees Fahrenheit. Even though this data looks like it supports the assumption that temperature directly correlates with the amount of illuminance but it doesn't. The recorded amount of lux for the highest temperature recorded of 80.20413672 degrees Fahrenheit was 853.5388184 lux. The amount of lux recorded for the highest temperature was less than the highest amount of lux recorded. All three trials for the CFL illuminance versus temperature were compared and even though the numbers were different that data still concluded to the same conclusion the there is no direct correlation between illuminance and temperature for the CFL light bulb in the 30 minutes time frame.

In table H-36, the first trial for LED Illuminance versus Temperature trials, the highest amount of lux recorded was 1081.381531 at a temperature of 76.26462036 degrees Fahrenheit. The lowest amount of lux recorded was 588.9056396 at a temperature of 78.37796237 degrees Fahrenheit. The lowest temperature recorded was 76.18109093 degrees Fahrenheit and had a reading of 673.0718994 lux. The highest temperature recorded was 79.00139125 degrees Fahrenheit and had a reading of 839.2098999 lux. From this trial alone the data does not support a correlation between temperature and illumination.

In table H-37, the second trial for LED Illuminance versus Temperature trials, the highest amount of lux recorded was 1114.041138 at a temperature of 73.55457478 degrees Fahrenheit. The lowest amount of lux recorded was 594.9728394 at a temperature of 77.5406129 degrees Fahrenheit. The lowest temperature recorded was 72.88680755 degrees Fahrenheit and had a reading of 681.0754395 lux. The highest temperature recorded was 77.87191301 degrees Fahrenheit and had a reading of 621.5652466 lux. The interesting fact about this set of data is that the difference between the amount of lux recorded at the lowest temperature and the amount

of lux recorded at the highest temperature is about 60. In table H-38, the third trial for LED Illuminance versus Temperature trials, the highest amount of lux recorded was 1021.613159 at a temperature of 78.03885995 degrees Fahrenheit. The lowest amount of lux recorded was 590.84198 at a temperature of 77.66583146 degrees Fahrenheit. The lowest temperature recorded was 77.62409235 degrees Fahrenheit and had a reading of 865.8023071 lux. The highest temperature recorded was 79.82056034 degrees Fahrenheit and had a reading of 900.6564331. This is the only trial that slightly supports the idea of there being a correlation between temperature and Illuminance, but the fact that the highest temperature recorded had a lower amount of lux recorded shows that there is no direct correlation.

H4.5 Conclusion

In conclusion I proved my hypothesis correct because the LED light bulb's percentage change of temperature was less than the CFL bulb for majority of the trials. I also noticed that there is no direct correlation between the amounts of lux versus the temperature. In the experimentation it is proved that the LED is a more efficient bulb. The LED bulb had only 820 lumens compared to the CFL bulb that had 825 lumens, but the LED reached a higher amount of lux than the CFL Bulb. The LED bulb managed to go over 1000 lux compared to the CFL bulb that never reached 1000 lux. The Luminous efficiency for the CFL bulb is 64 lumens per watt and the LED is 68 lumens per watt. The LED bulb is more efficient than the CFL even though the LED had less lumen, and watts. The LED light bulb is also safer than the CFL light bulb because even though both light bulb are capable of reaching higher temperatures the fact that the LED had a lower percentage of change shows that the LED bulb would take longer to reach a dangerous temperature and therefore the LED is safer.

H4.6 Next Steps

If I were to continue this project I would:

- Change the placement of the light and temperature probe to different spots in the box and see how that affects the data.
- Try to create environments using a wooden box and see if that changes the data. I would also try to compare my result to that of different light bulbs and bulbs with different wattage.

H4.7 Works Cited

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